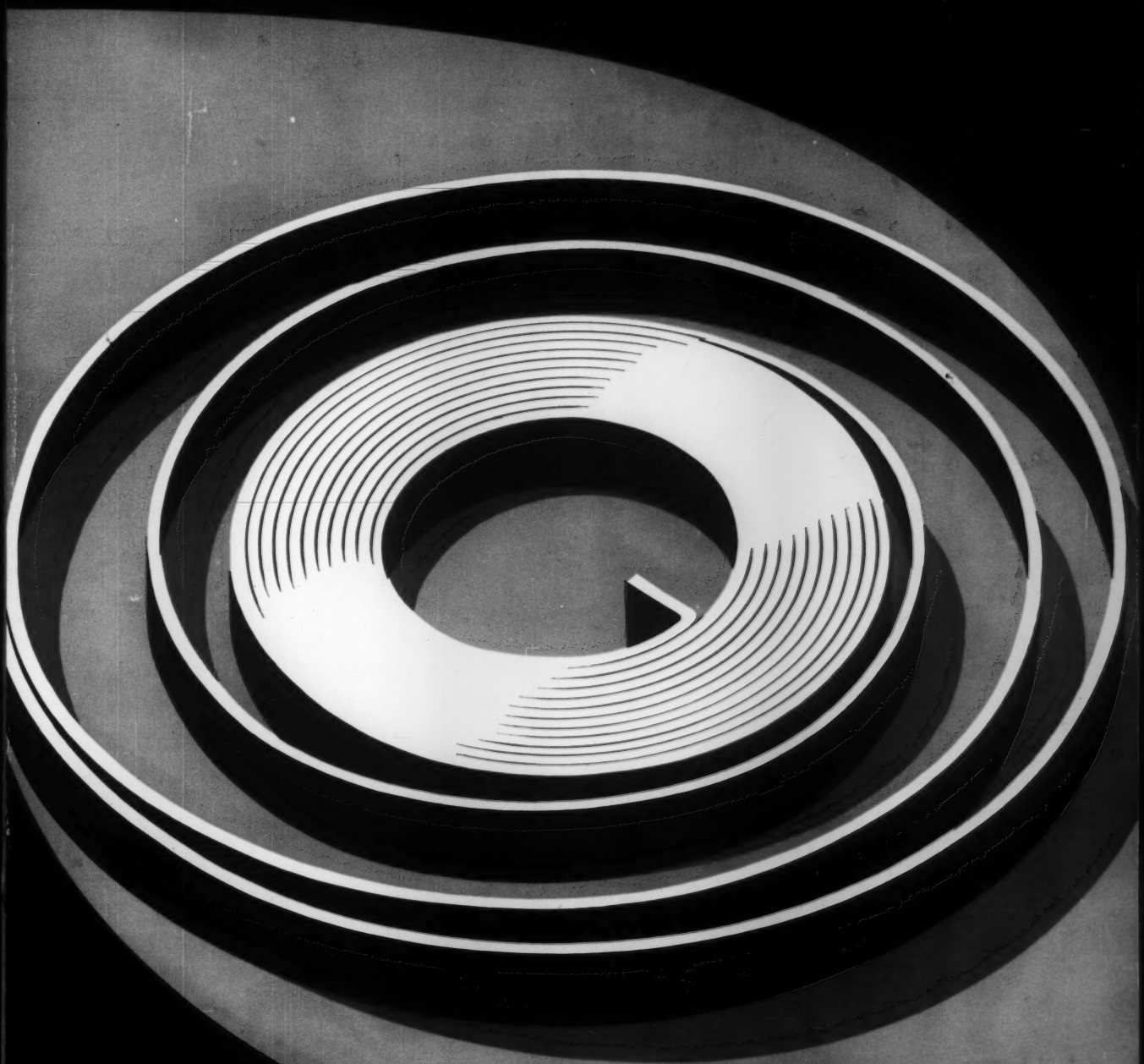
AUGUST 20, 1959

MACHINE DESIGN

A PENTON PUBLICATION – BIWEEKLY



Motor Springs

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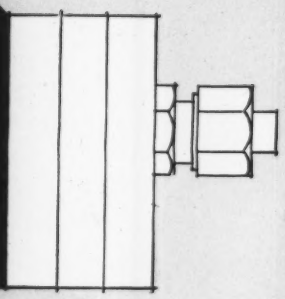
FARNSWORTH

off-the-shelf pumps just right for your requirements



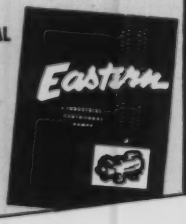
Whatever you want in a pump – for hydraulics, for flow or process control, there is likely to be an Eastern ready-made unit . . . made-to-order for your needs.

CAN YOU USE THESE PUMP FEATURES:

- ☐ corrosion resistant construction for chemical solutions?
- ☐ ability to handle organic and inorganic fluids at various temperatures with flows up to 70 GPM, pressures to 65 psig?
- ☐ available with open, enclosed or explosion proof motors?
- ☐ compact lightweight units with or without motor?
- ☐ high efficiencies in handling hydraulic oil, fuel and lubricants at high pressures?
- ☐ flow rates from 0.1 to 9.8 GPM, pressures from 0 to 1500 PSI?
- ☐ self-priming operation with non-lubricating liquids?
- ☐ high pressure outputs with small, low power units... and no contamination of fluid?
- ☐ flow rates from ½ GPM to 5½ GPM, pressures from 30 to 200 PSI?

An EASTERN CENTRIFUGAL PUMP MIGHT BE JUST RIGHT FOR YOU!

Write for Bulletin 120.



Look into EASTERN HYDRAULIC PUMPS!

Write for Bulletin 810

Get to know more about EASTERN POSITIVE DISPLACEMENT PUMPS!

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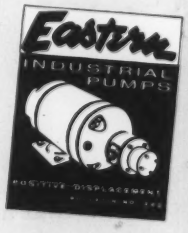

These useful brochures contain full specifications on the complete line in each category, including performance data and tables. They will be sent to you at no obligation whatever. Write Department R.

EASTERN INDUSTRIES PUMP DIVISION®

EASTERN INDUSTRIES, INC.

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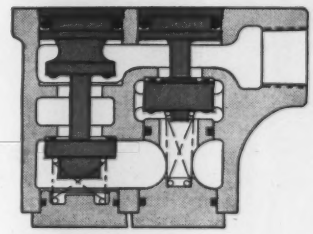
a basic Ross valve building block

4-way inline mounted valve body



- **Compact—saves space**
- **Ross quality**
- **Costs much less than base mounted 4-way**

Lots of designers use this valve where they must save space. It was designed specifically for compactness! Others use it to save money *without sacrificing* quality—when J.I.C. allows the usage of an inline valve, it meets J.I.C. specs. It's a unit of the Ross Skyline series which features modular construction, so it can be actuated with any Skyline series head. Ross poppet construction means pressure assists the seal, and short poppet travel gives faster response. On most applications it outlives the machine—and frequently doesn't even require maintenance. Write for Bulletin 321.

* WHITEMODEL SPOOL SOLENOID
* GOLDMODEL OIL-IMMERSED SOLENOID
* SILVERMODEL JIC SPOOL SOLENOID
GREENMODEL DOUBLE SOLENOID MOMENTARY
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BLUEMODEL AIR-OPERATED MOMENTARY ADAPTOR
BLUEMODEL AIR-OPERATED TIMED IN
BLUEMODEL AIR-OPERATED TIMED-OUT
*THIS AIR INDEX ADAPTOR CONVERTS THESE HEADS TO MOMENTARY ACTION

"every head meets every body at this gasket"

ALL SKYLINE HEADS AND BODIES ARE BUILDING BLOCKS TO GIVE YOU MANY VALVES FROM A FEW HEADS AND BODIES

ROSS OPERATING VALVE COMPANY

109 EAST GOLDEN GATE AVE. • DETROIT 3, MICH.

Circle 404 on Page 19

Another blueprint of better design–

–and a new idea in shock dampening!

Absorbing the crashing impacts between 120-ton freight cars was a tough job for even the heaviest of helical steel springs. So this big railroad equipment-maker decided to investigate the possibilities of rubber in designing a new kind of coupling draft gear.

The Goodyear experts then went to work with the equipment manufacturer's engineers. Soon they had come up with a new rubber compound of amazing toughness – molded it into shock-absorbing rubber-to-metal sandwiches, nine to a set.

Result: a new draft gear that provided far more impact-protection than anything else on the market.

Its recoil, for example, was only 18% – a low never reached before. It was, in fact, the first draft gear of its type ever to be approved by the railroad lines' own certifying agency.

Credit another success, then, to the resourceful technicians, in the well-equipped Goodyear molded/extruded plants, who have solved shock absorption and vibration problems in a wide range of equipment for many industries. To talk over your own molded/extruded rubber requirements – contact your local G.T.M.–Goodyear Technical Man. Or write directly to Goodyear, Industrial Products Division, St. Marys, Ohio, Los Angeles 54, California, or Akron 16, Ohio.

MOLDED OR EXTRUDED GOODS BY

GOODYEAR

THE GREATEST NAME IN RUBBER

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Front Cover: Motor or power springs, as shown by artist George Farnsworth, pack lots of punch into a small, pancake-shaped package. F. A. Votta and C. R. Leidigh compare several types in their article on Page 172.

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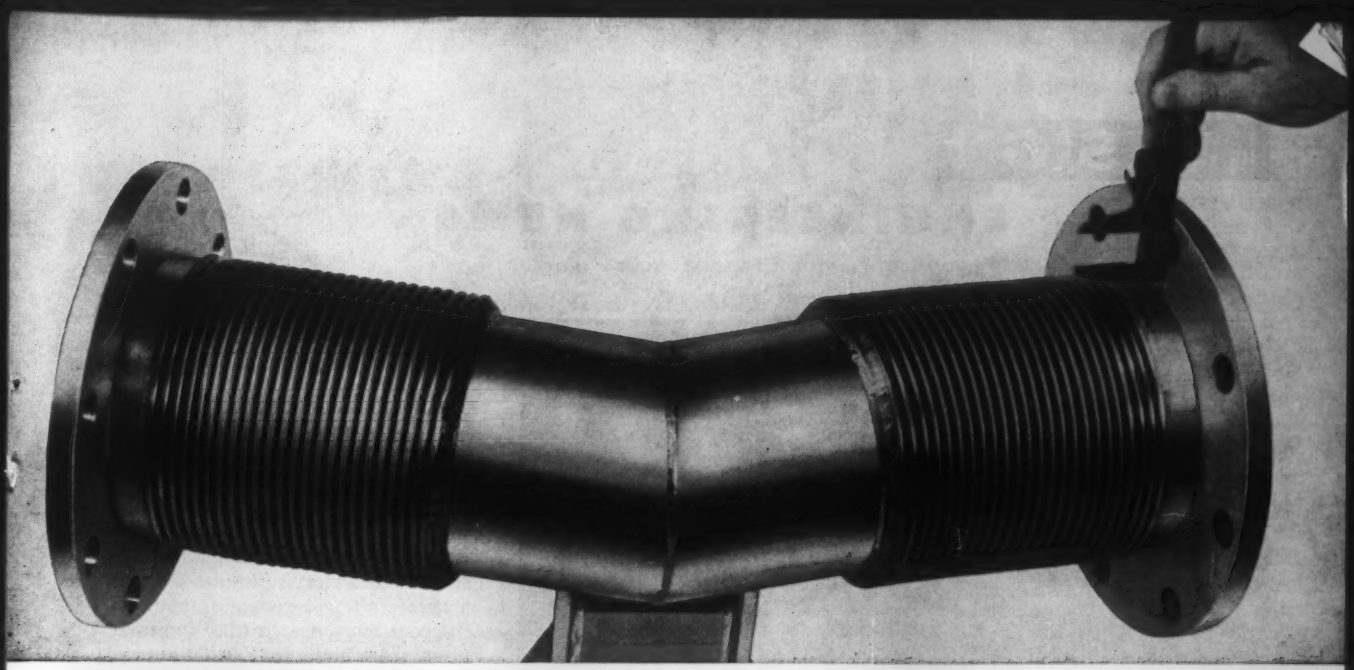

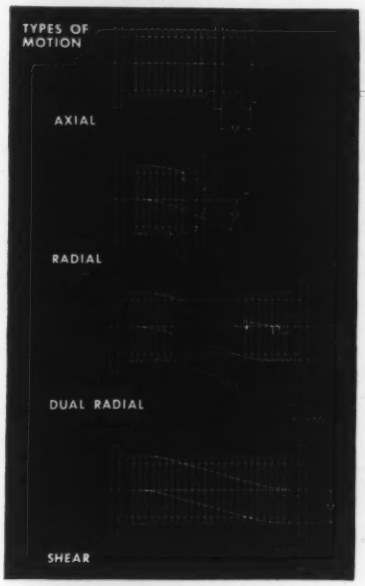

Expansion-joint tubing for big, tough jobs

New AX Tubing by Anaconda is available in Bronze, Stainless Steel, and other metals and alloys—from 4½" I.D. to 14" I.D.—to handle axial and lateral movement.

Need to compensate for contraction of piping suddenly cooled to minus 300°F by a large volume of liquefied gas? Want a bulkhead seal that "gives" with hull movement? Do you need a special assembly like that above, which handles an offset and a combination of lateral and axial movement? Wherever you need large diameter tubing to take care of movement shown in drawing at left, or simple offset, write: Anaconda Metal Hose Division, The American Brass Company, Waterbury 20, Conn. In Canada: Anaconda American Brass Ltd., New Toronto, Ont. 59128

ANACONDA® METAL HOSE

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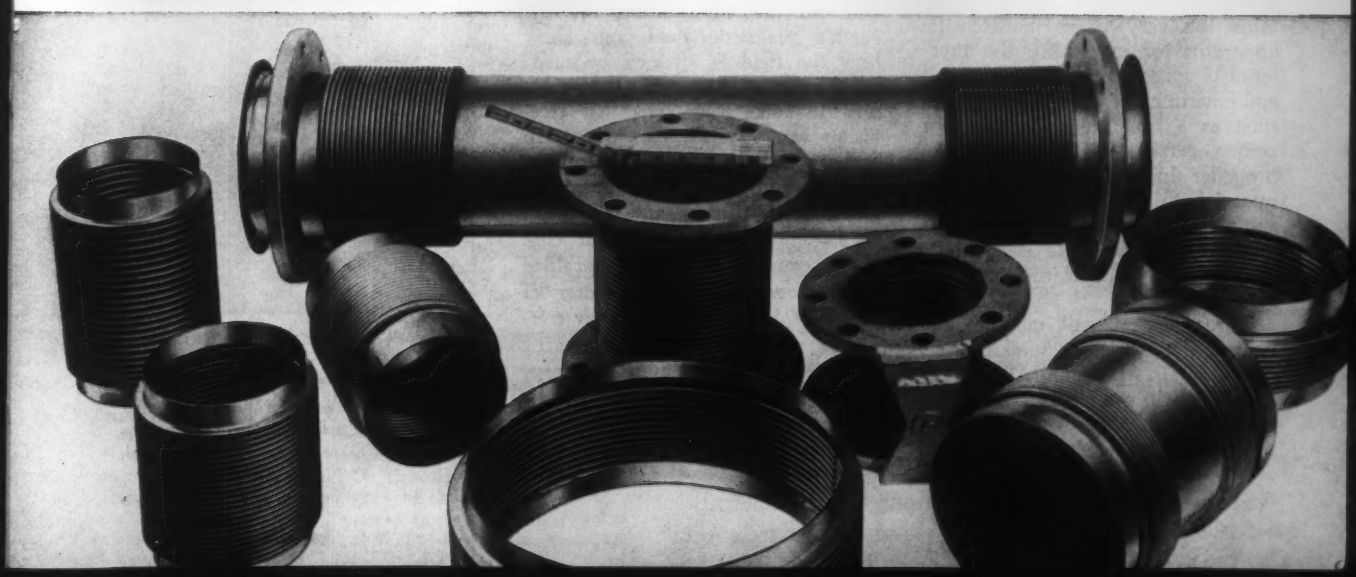

Shoulder-Fired Missile Added to Infantry Arsenal

Red-Eye, a new surface-to-air guided missile, proved so successful during feasibility studies that Army Ordnance recently awarded Convair Div., General Dynamics Corp., a $6-million contract for further development. Designed to give combat troops a better-than-even chance against strafing aircraft, the new missile can be transported and fired by one man. It is a composite structure containing propellant, high-explosive warhead, and an electronic guidance system. Because the launcher measures only 4 ft long by 3 in. diam and weighs only 20 lbs, the weapon can be carried in terrain where no other antiaircraft weapon can go. For shipment or storage, each missile is inserted in one launcher and the launcher is capped at both ends.

Paddle-Wheel Satellite Instrumented for Many Jobs

Limits of Van Allen Belts Will Be Established

WASHINGTON—Explorer VI, the so-called "paddle-wheel" satellite, contains the very latest in scientific apparatus for measuring the mysteries of space. In addition to orbit and environment control equipment, such as a small "kick" rocket for course corrections and a toylike propeller that turns a piece of black material to absorb or reflect the sun's heat for environmental temperature control, the vehicle is equipped to conduct several space experiments.

Three devices will measure the energy of the trapped solar protons contained in the Van Allen belts and will help establish height limits of those belts. Two radio transmitters and other instruments will determine composition of the ionosphere by studying its effects on transmitted radio waves of various frequencies. Two magnetometers will provide information on the earth's magnetic field and show how the field is affected by magnetic storms caused by explosions on the sun. One modified television camera will scan the earth and space. One detector will measure size and weight of cosmic dust particles encountered and will count frequency of contacts with particles.

Of course, the most heralded pieces of equipment on Explorer VI are the solar-to-electric energy converting paddle wheels. If powering satellite instruments by solar energy proves feasible, the paddle-wheel is sure to be incorporated in later deep space probes.

First Flights to Mars, Venus Simulated in Shock Tubes

Data Disagrees With Theoretical Predictions

LOS ANGELES—First trips through the atmospheres of Mars and Venus were recently simulated in the Lockheed Palo Alto Scientific Research Laboratory. Results indicate a spacecraft will generate about 50 per cent more heat in the Venutian atmosphere than in Earth's atmosphere.

This contradicts theory, according to Lockheed engineers. Theory predicted the atmospheres of Mars and Venus would be no worse a problem to designers than that of Earth. Test data, however, indicate the almost 100 per cent carbon dioxide atmosphere of Venus will cause greater friction, and temperature of the entering vehicle will rise commensurately.

Studies have been conducted in a 40-ft long by 3-in. diam shock tube. The atmospheres of each planet were simulated by filling the tube with the proper gases. A blunt-nosed shape, representing the

Nose cone being inserted in Lockheed's shock tube will come out blackened by shock waves traveling up to 14,000 mph. Because of the high temperatures of the gas, spacecraft velocities up to 20,000 mph can be simulated.

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. . . Fluid Power news

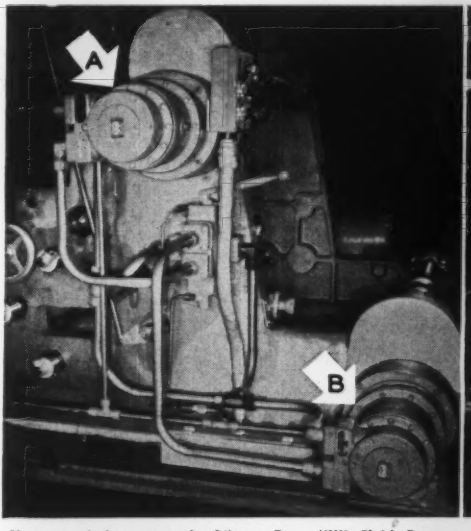
REPORT No. 12,300 HIGH PERFORMANCE WINDER DRIVES

From Oilgear Application-Engineering Files

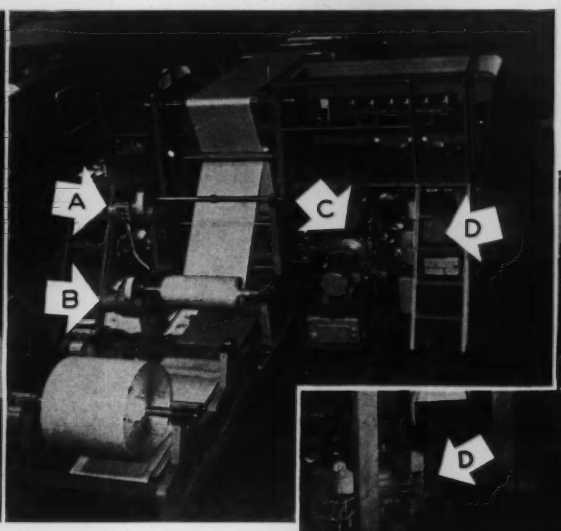
HOW OILGEAR PROGRESSIVE ENGINEERING PACES IMPROVEMENTS ON "BEMIS" MACHINES

CUSTOMER: *Bemis Bro. Bag Company, St. Louis, Missouri*

DATA: To efficiently produce the wide scope of paper, cloth, and polyethylene "Flexible Packaging" for which they are famous, "Bemis" designs and builds their own production machinery. Basically, "Bemis" machines are roll-fed, multi-color printing presses capable of very close register . . . operating from inching speeds of 15 fpm to running speeds of 400 to 1000 fpm. Press runs range from 1000 to 1,000,000 bags. Being roll-fed presses, winder drives and controls were a major problem, as ratios of 5:1 up to 10:1 from core to finished roll diameter are not uncommon. Paper widths vary from 10″ to 56″, with roll weights from 1000 to 2000 lb. "Bemis" specified that their winder drives must be compact; easy for shop, maintenance, and operator personnel to adjust, maintain, and understand. All electrical controls must be simple, with standard components preferred. Each machine to have one main control panel, and three or four remote, push-button panels — with some constant indication of load and tension as a desirable feature. Long, trouble and maintenance-free life was also of prime importance along with ease in installation.



Close-up of face-mounted, Oilgear Type "H" Fluid Power Motors (A, B), geared to rewind spindles of newest "Bemis" machine, shown center. Oilgear Type "D" Pump on "Power-Pak" (C) — center photo — supplies Fluid Power for rewind drive.



Newest "Bemis" press during "trial runs" prior to installation. Rewind motors (A, B) to left. Two Oilgear "Power-Paks" (C, D) with Oilgear Type "D" Pumps and Controls can be seen "tucked away" under the dryer section.

View "around-back" of new "Bemis" press dryer section, showing Oilgear Type "D" Pump and Controls on "Power-Pak" (D) which supplies Fluid Power to Oilgear Type "H" Motor (E) for main press drive. See "Note" below on Oilgear Pump (F), direct-coupled to tail-shaft of Motor (E).

SOLUTION: Through a program of constant improvement and engineering teamwork, Oilgear *Fluid Power* Drive and Control Systems have so successfully paced requirements for more efficient production equipment that "Bemis" plants in 16 cities now have 48 machines equipped with Oilgear winder drives. Dancer roll controls are used on 39 . . . 9 more recent installations have "*HYTAC SYSTEM" drives. Two newest machines (one shown above) have Oilgear Type "D" electrohydraulic servo controlled main press drives, and hydraulic servo controlled winder drives. One reason for this ever-increasing use of Oilgear "Any-Speed" drives has been clearly stated as follows: *"We put them in and forget about them . . . some have been operating for over 11 years without service or repair — many loaded to maximum capacity — others have had no oil change in five years"* . . . proof of the statement heard in all industry — *"For the lowest cost per year — it's Oilgear!"* One "Bemis" installation using a HYTAC SYSTEM winder drive handles 40 to 70-lb kraft stock 26″ to 63″ wide. This winder operates over a 13:1 ratio — from 3¼″ diam. cores to 43½″ diam. rolls — is limited only by interference on the machine. Of this HYTAC SYSTEM, "Bemis" states — *"Other types of variable speed drives could never do this . . . operating beyond our fondest hopes."*

*HYTAC SYSTEMS — An Oilgear Trademark

NOTE: *An unusual installation feature is partially visible on photo above. Oilgear Type "H" Fluid Power main press drive motor (E) is also direct-coupled to Oilgear Type "H" Pump (F) which supplies Fluid Power to an Oilgear Type "H" Motor — not shown — that drives the dryer fan.*

USER REPORTS — *" . . . exceptionally fine acceleration control . . . smooth creeping and inching speed up to maximum . . . exceptionally smooth running speed . . . are easier to adjust than other drives . . . require less space . . . pressure gage shows load while drive is in operation . . . maintain an adjustable tension from constant tension to constant torque."* "Bemis" — like other users — has found that Oilgear Drive and Control Systems give them constant tension, automatic tapering tension, stall tension, constant torque, automatic tapering torque, or a combination of tension and torque characteristics to meet their every production requirement.

For practical solutions to YOUR linear or rotary Controlled-Motion problem, call the factory-trained Oilgear Application-Engineer in your vicinity. Or write, stating your specific requirements, directly to . . .

THE OILGEAR COMPANY

Application-Engineered Controlled Motion Systems

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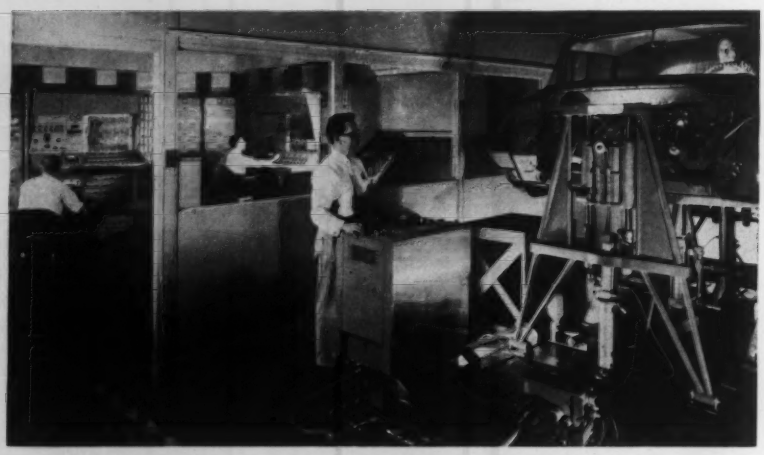
space vehicle, was located at one end of the tube, and the shock-wave generating ingredients (hydrogen, oxygen, and helium) were confined behind a copper diaphragm at the other. When the ingredients were ignited (by spark plugs), the combustion explosion blew out the diaphragm, releasing the shock wave's blast down the tube. With this technique, shock-wave velocities of 14,000 mph were attained.

As explained by Lockheed's R. W. Rutowski: "Because the gas is so hot, the free flight velocities simulated are even higher. In other words, we obtain the same heating that would occur in free flights of 20,000 mph."

While results with the simulated Mars atmosphere bear out theory, the Venus experiments indicate more exacting techniques will be required for a Venus landing than previously thought necessary.



Synthetic Travel Smooths Out Suspension Problems

Bounce, pitch, and roll, recorded on tape and played into an analog computer, help GM engineers solve equations in ride motion without using prototype cars and proving grounds. Standard auto body minus wheels and suspension replaces the regular car. Tires and suspension are programmed into the computer, which reacts in real time to the make-believe road effects. Car speed varies according to tape speed—controlled by the brakes and accelerator.

New Long-Range Radar Warns Of World's Missile Launchings

High-Frequency Waves Bounce Off Ionosphere

WASHINGTON—New type American radar signals may soon inform one central station of missile launchings virtually anywhere on the surface of the earth. The system has been extensively tested and proven over a period of about two years, and has been used to monitor both our own and Russian missile tests.

Developed under Project Teepee by Dr. William J. Thaler of the Office of Naval Research (Thaler's project, hence Teepee), the system's radar waves are like radio waves in that they bounce off the ionosphere. They are unlike conventional radar waves that travel only in straight lines.

Because the ionosphere—a thick layer of charged particles above the earth's surface—will reflect the new waves, radar range is extended to the missile pads of the enemy. A rocket rising after blastoff leaves a trail of hot, ionized exhaust gases. The new radar is reflected by these ionized gases and travels back to its "home station," again via ionospheric bounces.

The same basic techniques have been demonstrated practical in detecting a nuclear explosion thousands of miles away. Other possibilities and capabilities of the system are still being explored.

Topics

Stainless-steel choppers, fitted to some Colorado breeding cattle, are expected to lengthen the animals' lives by three to eight years. On the range, bovine life span is directly dependent upon the ability to perform self-service feeding; when a cow's teeth wear out, her career is through. To remedy this situation, a rancher and a dentist developed the metal molars and installed them in a dozen cows as an experiment.

• • •

Knowledge of electronics may automatically make one a musician if a new "instrument" catches on. An electronic music synthesizer, made by RCA, has been installed at Columbia University for the purpose of composition and research in electronic music. The machine is composed of a system of electronic circuits that can produce sounds made by any known instrument. It also makes original electronic sounds.

• • •

UFO's are on the decline: The sky-watching-populace beheld only 143 "flying saucers" during the first six months of 1959, a sharp contrast to 296 sightings during the previous six-month period. The Air Force, which investigates all reports of unusual aerial sightings, has reported on this year's activity to date: Of 143 "saucers" spotted, only 3 remained unidentified; 65 were astronomical phenomena; 30 were balloons and aircraft; 19 were a miscellany of searchlights, birds, hoaxes, etc. Not enough data were available to classify the other 18 per cent of the sightings.

• • •

Stereophonic hearing aid was developed by a Texas inventor who compares the principle of an ordinary hearing aid to an attempt to correct faulty eyesight with only one lens. The new spectacle-type instrument has separate sound equipment in each earpiece.

• • •

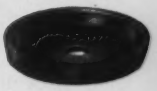
We get the picture of the atom incorrectly, according to Dr. Randall Caswell, chief of the neutron physics section of the National Bureau of Standards. The familiar symbol showing a nucleus with electrons orbiting it in symmetrical elliptical paths is about 30 years out of date, says Dr. Caswell. As long ago as 1926 scientists discarded this conception in favor of the "electron cloud" idea—exact location of the electron is not known, but its path can be pictured as a cloud, similar in appearance to the blur made by a spinning airplane propeller.

VALUE ANALYSIS where it really counts ... during design!

C/R Shaft Type Oil Seal

C/R Standard End Face Seal

C/R Sirvene Diaphragm



C/R Sirvis Molded Cup

C/R Rawhide Beveled Gear

Here's an expert at work, saving you money at the right time — during design. Like all C/R sales engineers, he's an experienced, well-trained representative whose knowledge springs from a solid engineering background. His ability to sit down with you during the design phase will help develop the most efficient and economical solutions to your problems.

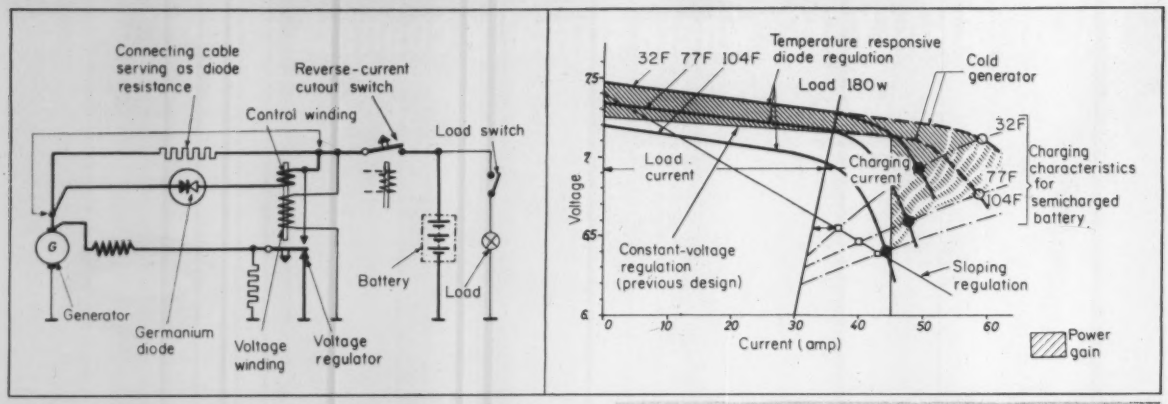
For example, he will often suggest design modifications that may save substantial production costs. Again, he will advise against specifications or seal types which he knows from experience will lead to service problems and user dissatisfaction. His personal "value analysis" of your fluid sealing problems, backed by the quality of these Chicago Rawhide products, can save you money. Welcome him when he calls to see you.

CHICAGO RAWHIDE MANUFACTURING COMPANY
1221 ELSTON AVENUE • CHICAGO 22, ILLINOIS

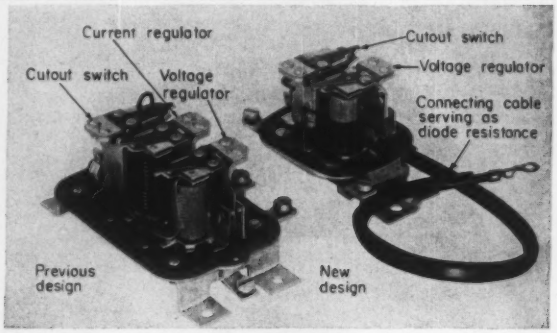
Offices in 55 principal cities. See your telephone book.
In Canada: Manufactured and Distributed by Chicago Rawhide Mfg. Co. of Canada, Ltd., Brantford, Ontario.
Export Sales: Geon International Corp., Great Neck, New York

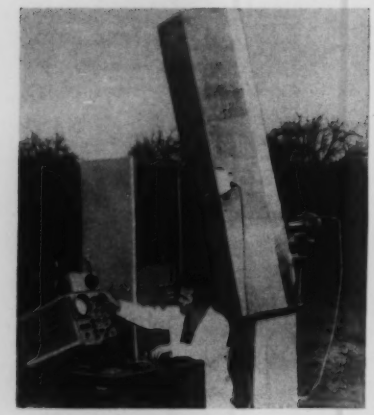
C/R
CHICAGO RAWHIDE

Diode Replaces Magnetic Switch in Car Voltage Regulator



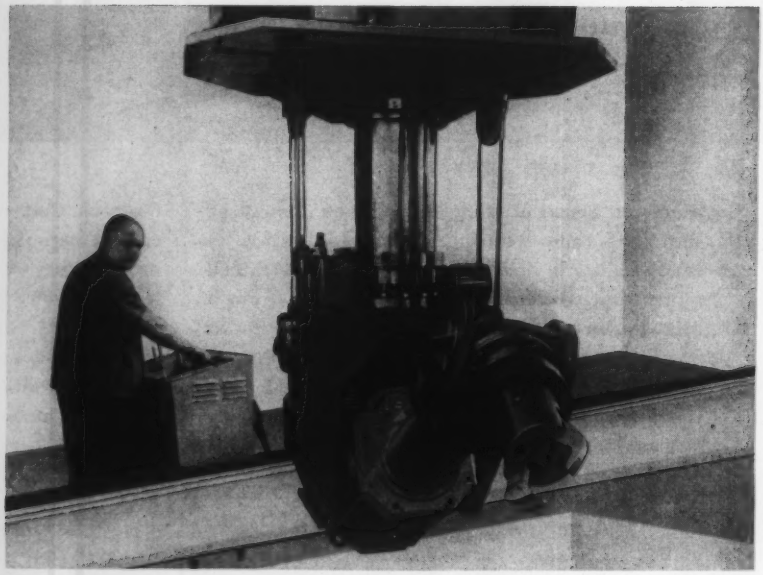
High-speed charging during first few minutes of engine run is provided by a new temperature-responsive voltage regulator designed in Germany. It uses a germanium diode as the current regulator in place of the usual magnetic switch. Voltage for diode control is produced by generator current passing through the resistance formed by connecting cable, above left: As generator current approaches permissible limit, increasing voltage drop across the resistance causes sharp rise in diode current acting on voltage-regulator control winding. Generator voltage is thus reduced and current kept within desired limit. Since transition from the constant-voltage to constant-current portion of the curve is temperature controlled, above right, higher load capacity of cold generator is utilized. Robert Bosch GmbH, Stuttgart, designed the unit.





Satellite Sleuth

Unique infrared tracker developed by ITT Laboratories, Nutley, N. J., uses a 19-in. mirror to collect infrared energy emitted by space objects. Mirror focuses energy on detector designed to measure infrared. As the tracker is able to detect satellites regardless of reflected sunlight or lack of radio signals, it may find use as a passive detection system for ICBMs. The device was developed for the Air Force's Cambridge Research Center, Mass.



Don't Shake Hands With It!

This heavy-duty manipulator can lift 2½ tons in its powerful grip. Los Alamos Scientific Laboratory will use it at a Nevada test site to disassemble reactors that are being studied for nuclear rocket propulsion (Project Rover). General Mills, developer, says that despite its great strength, the model 700 incorporates the full dexterity and precise control necessary to perform intricate tasks.

CASE HISTORIES

Exclusive Sentri-Seals effectively seal out foreign materials at temps up to 225° F for extended periods—up to 350° F for shorter periods. Made of Buna-N, they are compatible with silicone, petroleum and diester lubricants.

Photo courtesy: Thor Power Tool Company

Bearings Seal Out Abrasives...Allow Cool Operation In 21,600 R.P.M. Grinder!

CUSTOMER PROBLEM:
Tool manufacturer requires bearing design that will seal 21,600 r.p.m. grinder from abrasives . . . yet heat must be minimized for operator comfort since tool is hand held.

SOLUTION:
N/D Sales Engineer recommended a group of four New Departure integrally enclosed bearings . . . some with Sentri-Seals. These precision ball bearings successfully shut out microscopic grinding abrasives. And, even with such positive sealing, the virtually friction-free New Departures help keep the temperature low enough for comfortable hand operation. They're sealed and lubricated for life . . . promising trouble-free ball bearing performance without the added burden of periodic maintenance.

For immediate analysis of your current ball bearing problems, call the New Departure Sales Engineer in your area or write Dept. Q-8.

Replacement ball bearings available through United Motors System and its Independent Bearing Distributors

NEW DEPARTURE
DIVISION OF GENERAL MOTORS, BRISTOL, CONN.
NOTHING ROLLS LIKE A BALL

Proper Fuels and Oils Silence Engine "Rumble"

Combustion Research Points Way To Higher Compression Ratios

VANCOUVER, B. C.—Auto engine "rumble" can be silenced by careful selection of gasoline and oil, three members of General Motors Research Laboratories told SAE's recent International West Coast meeting.

Rumble, they said, usually occurs during passing or hill-climbing—when engine loads are high. It results from excessive pressure buildup in the combustion chamber when hot engine deposits set off several "flame fronts" in the air-fuel charge. These, of course, are in addition to the normal ignition front of the spark plug.

R. F. Stebar, W. M. Wiese and R. L. Everett of GM Research Fuels & Lubricants Dept. said this pressure buildup generates a low-pitched, rapping noise, or resonance, in the crankshaft main-bearing zone of the engine. Audibly unpleasant, rumble also robs an engine of some of its power.

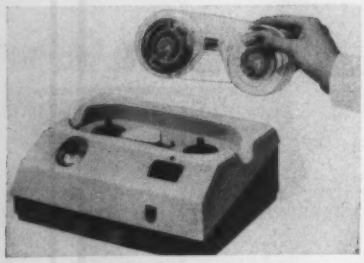
Tests indicated that "certain crankcase oils form combustion-chamber deposits which cause more rumble than other oils." Generally, the new 10W-30 oils had better rumble ratings than others.

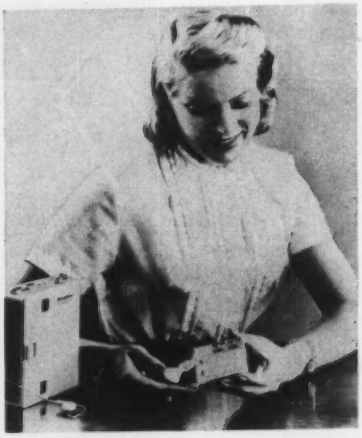
The GM men found that fuel affects rumble in two ways: 1. By deposits it forms in the combustion chamber when it burns. 2. By its inherent resistance to deposit ignition when exposed to high temperatures and pressures in the combustion chamber during the compression stroke.

Most effective in silencing rumble were fuels with phosphorus additives. This is because phosphorus combines with tetraethyl lead during combustion, forming lead-phosphorus compounds that are less likely to cause deposit ignition.

The gas researchers also found that humidity has a big influence on rumble: Noise decreases as atmospheric humidity increases. Likewise, increasing inlet air temperature raises an engine's rumble requirement.

Report concludes that engines with 12 to 1 compression ratio won't rumble on the right fuel and oil.





Reel Help for Fast Talkers

Cartridge loading is a convenience feature in the lightweight office recorder, above, designed by Deutsche Philips GmbH, Germany. Plastic cartridge holds 214 ft of long-playing tape on two 3-in. diameter reels. For on-the-go executives, Dictaphone Corp. has developed a tape reel so small it can be mailed in an ordinary letter envelope and dropped down a standard mail chute. The reel, right, weighs just over 1 oz, is 2½ in. in diameter by 7/16 in. thick, and holds 50 min of recording.

Metals Matters

Protective jackets . . .
for atomic fuel elements in the Argonne Low Power Reactor will be made of an aluminum-nickel alloy developed by Argonne National Laboratory for the purpose. Problem faced was hydrogen penetration of the metal. The best combination was an alloy obtained by adding a small amount of nickel to alloy 1100.

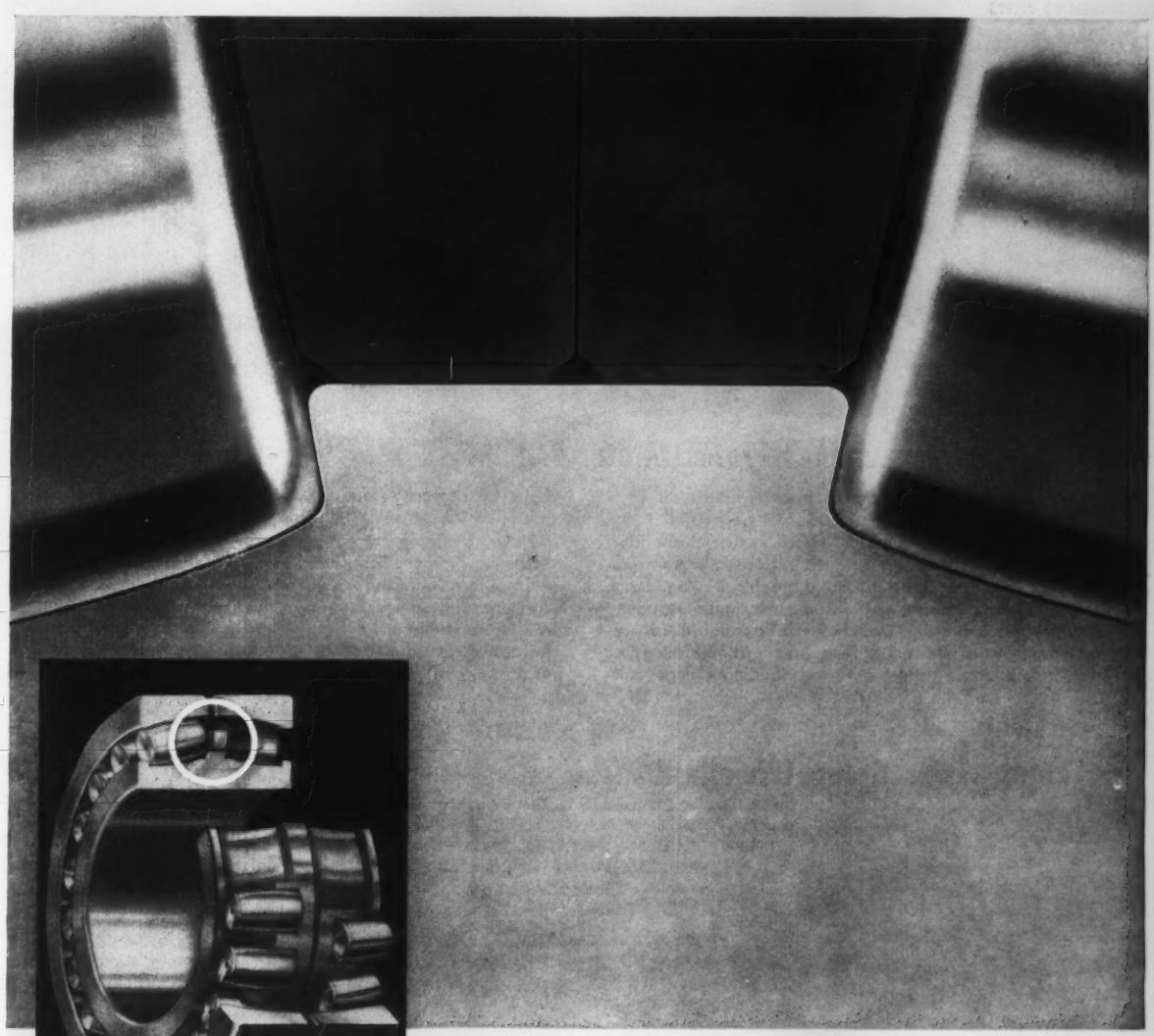
New uses for mercury . . .
are being sought at Battelle Memorial Institute by the American Quicksilver Institute. Uses evaluated will include powder-metallurgy techniques to produce porous metals, amalgam metallurgy techniques, and as an intermediate agent in the production of exotic fuels or oxidizers. Interest is in applications involving complete consumption or recycling of mercury.

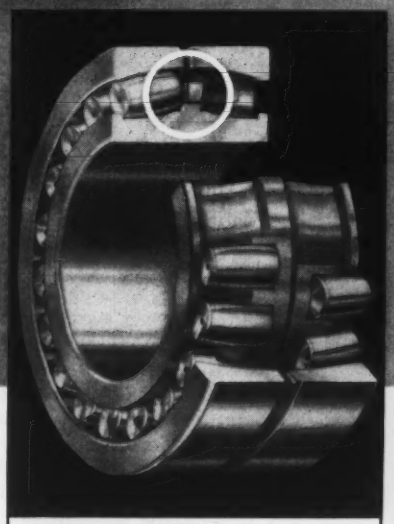
Misconceptions about scarcity . . .
of cobalt have led designers to avoid specifying cobalt alloys or cobalt dyes, says Dr. F. R. Morral of Battelle Memorial Institute. He adds that the impression stems from the days of the Korean conflict when world cobalt production was sufficient only to fill the needs of jet-engine designers. However, world production of cobalt jumped from 4000 short tons in 1946 to 16,300 short tons in 1956 and is expected to be over 20,000 short tons in 1959. If demand warranted it, free-world production of cobalt could be 25,000 tons per year says Dr. Morral.

Wrought zinc alloys . . .
with improved mechanical properties are expected to come from powder-metallurgy techniques being studied at Rensselaer Polytechnic Institute says the American Zinc Institute. Expected properties will be the result of interference hardening in microstructure. A uniformly fine grain size can be obtained by starting with powder, says Dr. S. F. Radthe, research director for AZI. Another technique under study introduces an insoluble second phase into the metallic matrix.

Gold deposit . . .
can be built up evenly to any thickness by means of a new chemical process developed by Everlube Corp. of America, North Hollywood, Calif. The process does not require an electric current, nor is it an ion-exchange process, say its developers. The gold surface is an excellent conductor and and ideal solder base, since it does not corrode.

Smaller transformers . . .
can be designed to do the job if the core is made of a new electrical steel with preferred crystal orientation now in production, says Armco. The new steel, designated Oriented M-5, limits core loss to 0.58 watts per lb under standard conditions of 15 kilogausses and 60 cycles. This is said to be a 10 per cent improvement over the best grade of electrical steel commercially available until now.





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Spherical Roller Bearings Offer:

- inherent self-alignment
- conformity of rollers to raceways
- integral center guide flange for stability
- positive roller guidance
- land-riding bronze cages
- maximum radial and thrust capacity
- controlled internal clearance
- electronically selected rollers
- even load distribution
- long, dependable service life

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The integral center guide flange of the *Torrington* Spherical Roller Bearing provides *positive* roller guidance—the one best way to insure operating stability under radial and thrust loads.

Center guide flange surfaces and roller ends are ground to a common spherical radius. The asymmetrical roller seeks this flange under load, bearing lightly but constantly against it. Roller wobble and skewing are eliminated, and stress concentrations leading to early failure are avoided. Bearing operation is cooler, quieter and smoother.

The integral guide flange is adapted from the same principle used in the design of Torrington Tapered Roller Bearings. It is an engineering refinement, based on experience in all types of applications, that insures outstanding performance in your equipment. **The Torrington Company, South Bend 21, Ind.—and Torrington, Conn.**

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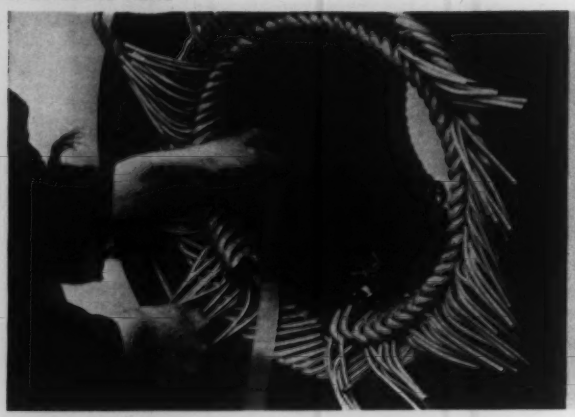
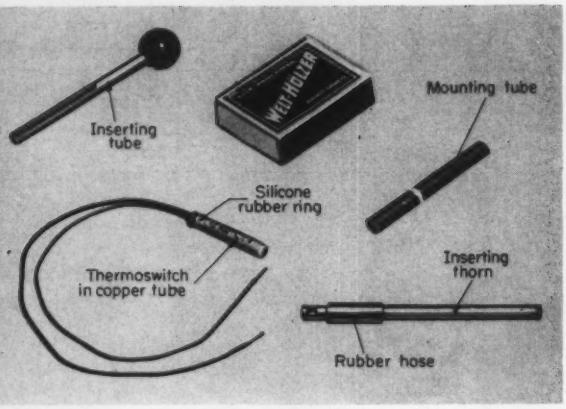
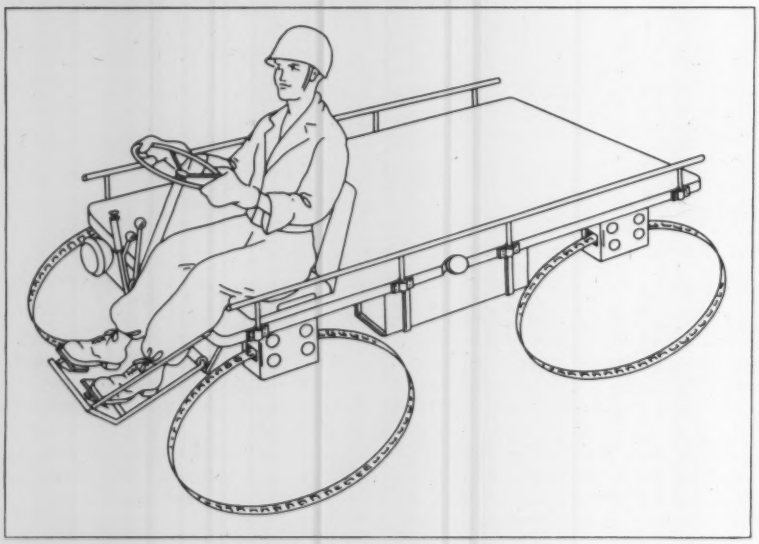




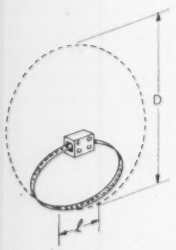
Imbedded Thermoswitches Protect Motor Windings

Miniature bimetallic thermoswitches imbedded in coil ends of an electric motor respond to sudden temperature rises to shut off the endangered motor. Each switch, suspended in a silicone rubber holding ring to reduce vibrations, is contained in a copper tube 1/4 in. diam by 1 3/8 in. long. Low thermal inertia of the unit insures maximum response to winding temperature. Switches are available for response temperatures from 122 F to 360 F at tolerances of ± 7 F. Insulation is tested at 3 kv, making design suitable for motors rated up to 600 v, starting with approximately 5 kw power. Switching capacity is 1 amp at 220 v, 50 cps, avoiding the need for an auxiliary relay. Manufacturer, Siemens-Schuckertwerke AG, Erlangen, Germany, warns that miniature switches are merely to supplement conventional protective switches, not to replace them. Miniature thermoswitches, set to a lower response temperature, actuate optical or acoustical warning devices which signal the operator to reduce the load.

Army Mule Tries Going Wheelless



Elastic rims driven by sprockets will replace the wheels on an experimental 1/4-ton Mule at Army's Detroit Land Locomotion Lab. Although radical, the spokeless, hubless prodigy may have some notable merits: Its maneuverability in mud and snow should be exceptional, due to lack of lateral wheel resistance, and a relatively small elastic wheel (right) has the same ground contact length, **l**, as a conventional wheel with much greater diameter, **D**.



Comfort, Reliability Stressed for Astronauts' Suits and Chutes

DAYTON, OHIO — Clothing for Project Mercury's man in space will include a modified Navy flight suit designed by B. F. Goodrich Co., Akron, Ohio. The double-walled rubber suit won over two rivals in six month's testing at Wright Air Development Center. Mobility, compactness, reliability, resistance to temperature, pressure integrity, and ease in getting in and out of the suit were first-order requirements. One of the astronaut candidates was on the six-man NASA board that chose these factors.

Inner layer of the suit is perforated to permit the pores of the body to "breathe." Air inlet is at the waist; outlet is from a valve in the helmet. Air will be circulated through a special air conditioning and purifying system under the pilot's seat in the capsule. The suit will be inflated if the capsule pressure fails.

Chutes that can open safely at 25,000 mph are also sought by Wright Air Development Center. Present chutes are used by pilots who bail out at up to 1000 mph. For nose cone and satellite recovery, chutes will undergo thermal

and mechanical stresses that would destroy chutes made of conventional materials. American Machine and Foundry Co. will study chutes made of synthetic textiles, as well as metal and glass fibers. Along with high-temperature strength, weight is an important factor in fabric choice: Every pound put into orbit requires 1000 pounds of propellant in the initial charge.

Not-So-Rare Titanium Yields to Electrolysis

Ductility and Machinability Are Superior to Standard Form

WORCESTER, MASS. — Titanium is called rare only because of the problems involved in producing it in pure metal form. Although it is the fourth most plentiful structural metal, it has been commercially available for only the past ten years. Production in 1958 was 4500 tons. Price is about $9 per lb. It is known as a brittle, hard-to-machine metal, but it's as strong as steel and half as heavy.

Ductile titanium can now be made by a newly developed electrolytic process which also gives promise of making the metal less expensive to produce. Starting point for the process is titanium carbide which forms the anode of an electrolytic cell. During electrolysis, the titanium is separated from its carbide and adheres to the cathode in the form of dendritic (branch-shaped) crystals of pure titanium metal. These crystals can be melted into ingots or used directly in powder metallurgy techniques. Chemical analysis of the crystals indicates a purity of 99.6 per cent.

The experimental cell made batches of up to 12 lb. It required 8 to 10 kw-hr of electricity per pound of titanium produced. Although the laboratory cell used to develop this process was not large enough to establish reliable cost estimates, Norton Co., Worcester, Mass., is confident that titanium metal can be produced economically. Chief economy is high titanium content of the inexpensive raw material. Titanium carbide contains about 80 per cent titanium; it can be made from ilmenite which is domestically available.

DRAFTING TRENDS

Convenient refilling for drawing pens with POST's foolproof, spillproof plastic container. New ink package eliminates mess of conventional dropper stopper filling.

Foolproof feeding for drawing pens

A fresh packaging idea finally ends the annoying problems involved in filling your pen. Gone is the time-consuming mess of pen filling from conventional bottles, thanks to a new squeeze-bottle container from POST.

The poly plastic bottle feeds ink directly to your pen through a clog-proof nozzle (providing it is recapped after use). Even if the uncapped bottle drops, there can be no serious damage since it requires pressure to dispense the ink.

Another plus feature of POST's new poly containers . . . They come packaged in a sturdy carton which is designed to serve as a reliable base for holding the bottle.

In addition to the blackest of India blacks, POST supplies the new containers with a whole range of intense colors—13 brilliant hues in all.

Improved drafting tape in dispenser package

POST comes up with another packaging improvement to make life at the drawing board more pleasant. Now you can buy POST pressure-sensitive adhesive tape in a package with a built-in cutting edge. This does away with uneven tearing. And unlike earlier masking tapes, drafting tape with the POST trademark will not stretch out of shape when you apply it, will not leave any gummy residue when you remove it, will not "ghost" on tracing cloths or vellums.

Why not keep posted on all *the new trends in drafting? Just consult your local POST dealer. Or write to Frederick Post Company, 3652 North Avondale Avenue, Chicago 18, Illinois.*

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(Advertisement)

Management is looking for men who can "Run the Show"

The future was never brighter for men who have the knowledge, ability and desire to become administrative executives . . .

by
James M. Jenks

Like the average football coach, some executives refuse to admit that next season's "team" may be a winner; they're eternally pessimistic when it comes to forecasting success.

Unfortunately, many individual organizations today have a legitimate cause for concern. It is a statistical *fact* that the incidence of business failures has always been discouragingly high. And the main reason for this—according to Dun & Bradstreet and other authorities—is a "*lack of managerial ability*".

Even the biggest companies are hard-pressed to find people capable of shouldering the diverse responsibilities of top-level management positions. It's easy enough, they say, to hire qualified *specialists*. But somebody has to coordinate the activities of all departments. Somebody has to "run the show".

And it is in this vital area of general administration that an acute shortage of able personnel exists.

Industrial Expansion a Factor

As one writer recently pointed out, "The rapid and extensive growth of industry has created a lost generation among young executives". Under present "speed up" conditions, there simply hasn't been time for these people to acquire broad, practical experience in all phases of business. So, quite naturally, they specialized in one.

Their limitations become apparent only when they're promoted out of the niche in which they have become experts, and are confronted with an entire set of *unfamiliar* business problems.

It is then painfully obvious that—for the management man—there is no substitute for a well-rounded knowledge of the basic principles of business. For him, nothing can take the place of knowing how a business operates—how each department relates to the enterprise as a whole.

The Modern Way to Acquire the Knowledge You Need to Succeed as an Executive

Managing is an art. And, like any other art, it is based upon a science. Just as the art of surgery, for example, rests upon the science of anatomy, *the art of management evolves from the science of business*. It follows, therefore, that no man can get very far in business without having first mastered the "anatomy" of business—the principles on which it operates.

For fifty consecutive years, the Alexander Hamilton Institute has specialized in bringing this knowledge to mature men—at home in their spare time.

Free . . . "Forging Ahead in Business"

The Institute's program is outlined in a 48-page booklet titled "Forging Ahead in Business".

It is a fascinating little book about how success is achieved in business . . . not through any magical formula, but by the application of a practical, time-tested plan which has been developed over the years by a distinguished group of academic and business leaders. We believe that it will help any man get down to bedrock in his thinking; however, there's no cost or obligation for it because—frankly—we've never been able to put a price on it that would reflect its true value. Some men have found a fortune in its pages.

If you would like a complimentary copy of "Forging Ahead in Business", simply fill out and return the coupon below. It will be mailed to you promptly.

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USE A YELLOW CARD *for More Information . . .*

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EDITORIAL CLIPSHEETS—So you won't have to "clip" this issue, we'll be glad to send a personal copy of any article as long as the supply lasts. Just fill in the page number and title of article in the place provided on the Yellow Card.

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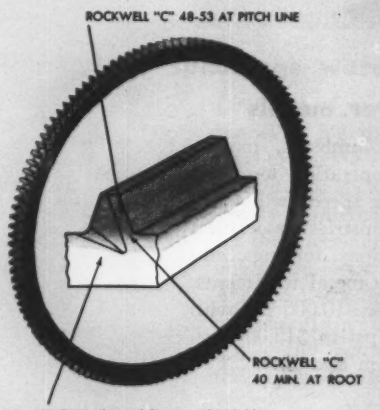
To the Outboard Motor Industry

on its

GOLDEN JUBILEE

At the end of its first half century the outdoor motor industry can regard its "family of fans" with pride—all 35,000,000 of them. Today almost 25% of this nation's population find fun, recreation, even employment in outboard powered craft.


ROCKWELL "C" 48-53 AT PITCH LINE
ROCKWELL "C" 40 MIN. AT ROOT
DUCTILE BODY ROCKWELL "C" 10-20
SHADED AREA IS HARDENED WORKING SURFACE

DOUBLE DIAMOND'S CONTRIBUTION

Major makers of electric-starting outboards come to Automotive Gear for their flywheel starter gear requirements. They receive our extensive experience in making millions of them for the automotive field—plus skilled engineering aid—plus respect for their specifications—plus localized hardening for better, longer gear performance—plus good delivery.

If you are powering a product, why not talk to the company that specializes in power transmission via gears of many types? An engineer will respond to your inquiry.

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GEAR-MAKERS TO LEADING MANUFACTURERS

Circle 413 on Page 19

low-cost porcelain enamel competes with paint

Designers of sheet metal products can now specify a one-coat porcelain enamel that costs little enough to compete with paint surfaces now used on many refrigerators and stoves. Nonpremium steels coat as well as premium enameling steels and cost $10 a ton less. Coatings are tougher and more flexible than conventional porcelain coatings. Annealed and cleaned sheets are coated with nickel (0.08 gm per square foot) as a base for the frit. Porcelain coat is fired at 1450 F. Ferro Corp., Cleveland, says some customers have been testing the porcelain for more than a year with excellent results.

precision welding aids electronic miniaturization

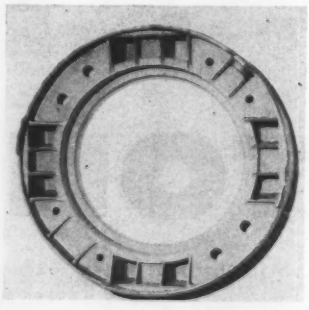
Miniaturized electronic packages are compressed to a component density of more than 100 parts per cu in. in a new precision welding technique developed by Raytheon Mfg. Co. Over 300 welds per cu in. are reported possible, and since components are literally welded together, conventional leads are eliminated. Current leakage problems are virtually eliminated, says Raytheon, and the welding technique minimizes heat transfer to components as connections are made.

aircraft designers spearhead demand for better metals

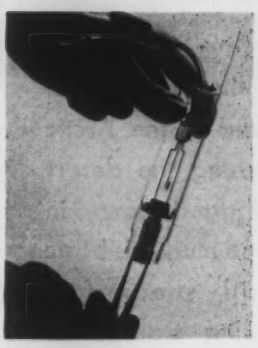
Increased dependence on refractory metals—tungsten, columbium, molybdenum, and tantalum—will follow the trend to higher operating temperatures for aircraft. By 1970 the heat of Mach-3 or higher speeds will leave beryllium almost out of the picture, predicts Aerospace Industries Association of America Inc., Los Angeles. Heavy bars, plates, extrusions, forgings, and castings will also give way, in many cases, to lighter sheet-metal weldments. Strength of die steel will jump from 270,000 psi to well over 410,000 psi, with low alloys right behind, increasing from today's 190,000 psi to 315,000 psi. Plating will be nickel and chromium, rather than cadmium and zinc.

super strength for steel casting

Steel castings with tensile strengths approaching the 300,000-psi mark are coming from American Brake Shoe's Research Center in Mahwah, N. J. A typical 8740 casting has 285,000 psi ultimate strength, 230,000 psi yield strength, and 4½ per cent elongation. Castings of other steels show comparably high values. Secret, say metallurgists, lies in use of high-purity ingredients and close control of production.



transistorized vacuum tubes next

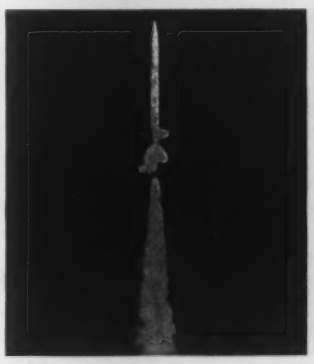


Experimental vacuum tube under development at Westinghouse Electric Co. gets its supply of electrons from a silicon carbide crystal the size of a pinhead. The crystal replaces the hot, power-consuming cathode usually found in electron tubes. The experimental tube depends upon a new form of electron emission discovered in a semiconductor material, silicon carbide. Successful application of the discovery would result in a "solid state" tube that would combine the advantages of tubes and transistors.

"electrified" plastics show boost in strength

Tensile strength of polystyrene can be increased 25 per cent by processing the plastic in an electric field and at the same time subjecting it to external heat, according to preliminary data from Armour Research Foundation. Evidence to date has prompted Armour scientists to take a further look at mechanical and electrical properties of all the common plastics. They are also evaluating feasibility of improving elasticity and tear strength of various plastics by the same process.

space-age water power



Low cost of steam-powered rockets is responsible for the revived interest in this type of engine evidenced at the American Rocket Society's recent Ohio State University conference. Obvious application for the space-age steam engine is in a low-energy research rocket, spokesmen report. A second possible use is in retro rockets on re-entry vehicles—aerodynamic heating would convert water to steam, cool the vehicle in the process.

oil mileage in '60 cars—more or less

Depending on what kind of car you drive and who you ask, recommended mileage between oil changes varies from 500 to 5000 miles. Oil industry and automakers have been quietly feuding over the subject for a number of years and may end up in an open skirmish when the '60 cars are introduced. Crux of the controversy: Competitive reasons have forced automakers to gradually recommend more mileage between oil changes—up to 5000 miles on some models. This alarms oil men, who say 2000 miles is the absolute safe maximum. Automakers, nonetheless will stick to their mileage figures during the coming year and back their claims by equipping more new models with full-flow oil filters.

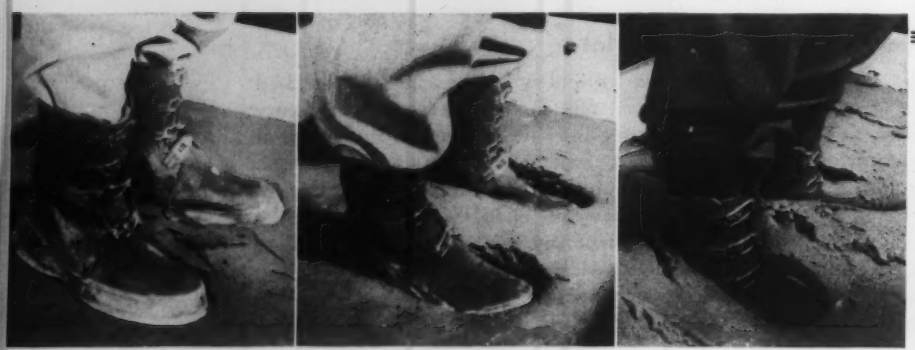
Consider the mechanized GI snowbound in the Arctic wastes, churning the desert sand, or bogged down in spring-thawed mud. His basic problem—soil shear failure—is leading transportation researchers to dig into properties of . . .

Mud, Snow, Sand

IF AN ENGINEER were told to design an aircraft for operation on the planet Mars, he would ask for at least two atmosphere values—density and viscosity. An engineer who designs an off-the-road vehicle for a remote part of the world needs similar information. Yet he has never had any measure of the medium in which his vehicle is to operate.

This situation has been realized, but since no method of soil measurement from a locomotion viewpoint has ever been developed, it has been impossible to identify and measure pertinent soil conditions.

Since soft-soil information is lacking, testing has become so controversial that comparison of agricultural tractors has had to be based on hard-ground testing. On hard ground, however, all vehicles



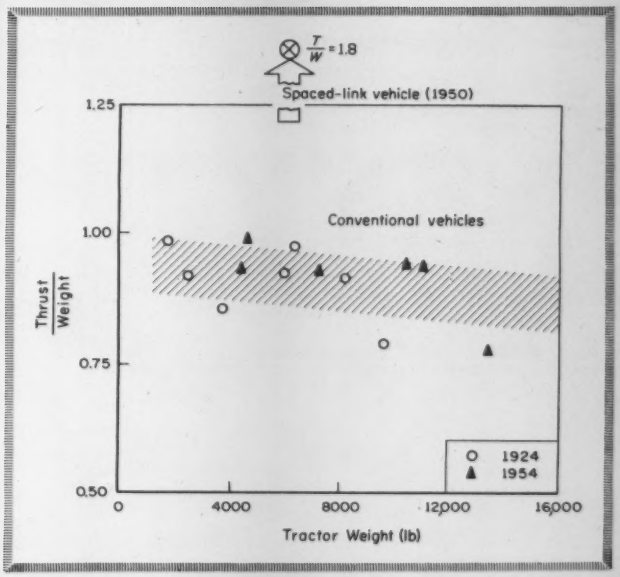
Support that a soil can give is very sensitive to moisture content. A man stands on the surface of soil with 19 per cent moisture content (left). With only 1 per cent addition of water he starts to sink (center). The same soil with a moisture content of 22 per cent lets him sink well over his ankles (right).

Snow, mud, and sand are soil extremes that cannot be managed efficiently with a single vehicle design. Where a variety of conditions are to be encountered in a single operation, operations research must weigh the conflicting needs to decide on the best compromise design configuration.

M. G. BEKKER
Chief, Land Locomotion Research Branch
U. S. Army Ordnance
Tank-Automotive Command
Detroit, Mich.

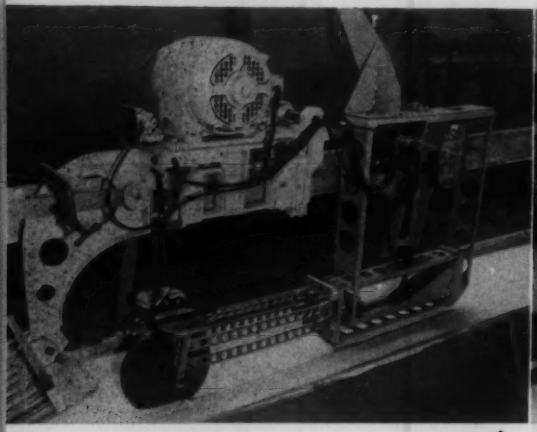
are practically alike. So vehicle forms have been frozen for decades.

The result: Stagnation in performance. Ratio of thrust to vehicle weight has not changed for 30 years. Since that ratio determines the efficiency of the vehicle, the

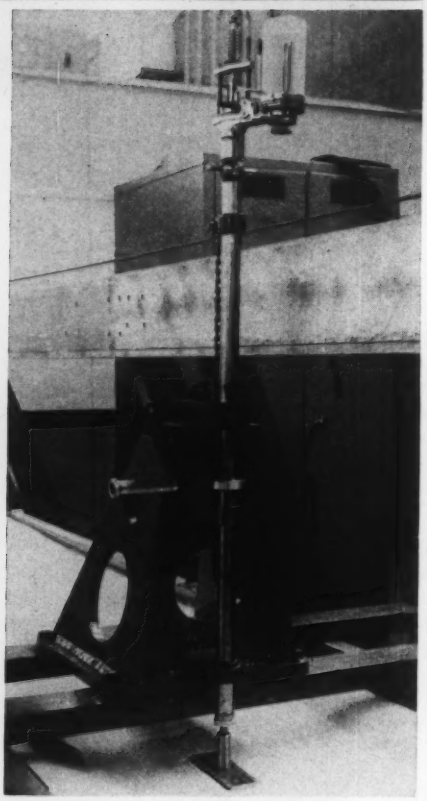


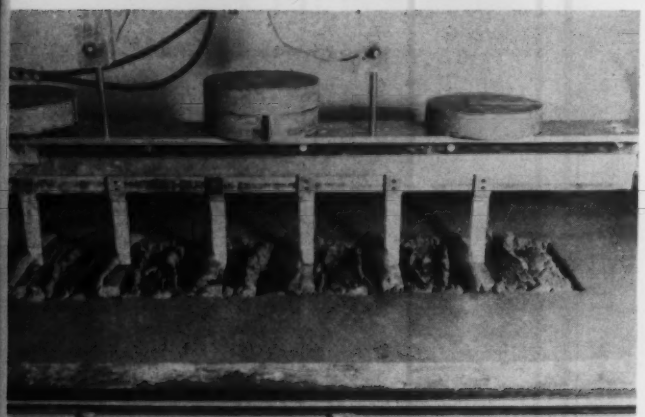
Failure of track design to improve in 30 years shows up in this plot of thrust-weight ratio versus weight. Modern vehicles show no trend away from thrust-weight ratios typical of the twenties.

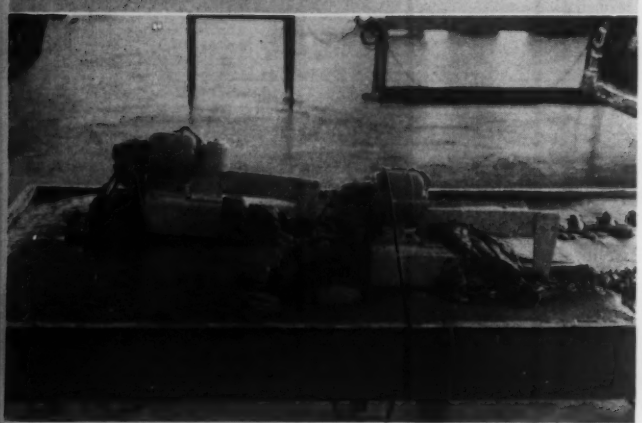
Shear strength is a property of soil under study at Land Locomotion Laboratory. Pattern of shear failure is similar to that of a semifluid. Note the upward thrust of the soil far ahead of the blades.



Parameters for soil sinkage are determined at the Detroit Laboratory with testing devices which use a static foot, or a wheel to measure sinkage under controlled conditions.







Model of a track design proposal is tested in artificial clay (top). Later, model tracks are built and run in competition with standard track (below). Spaced-link track being tested uses widely spaced cleats to develop full shear potential of soil. Note leading vehicle's track indentations at extreme right.

advantage of better fuels, lubricants, engines, and transmission cannot materialize until the running gear itself can be improved.

Soil changes which occur with small changes in water content are enormous. Changes caused by small variation in mineralogical and geological soil structure also present a

variable environment. It is not likely that the same vehicle will operate as well in all conditions.

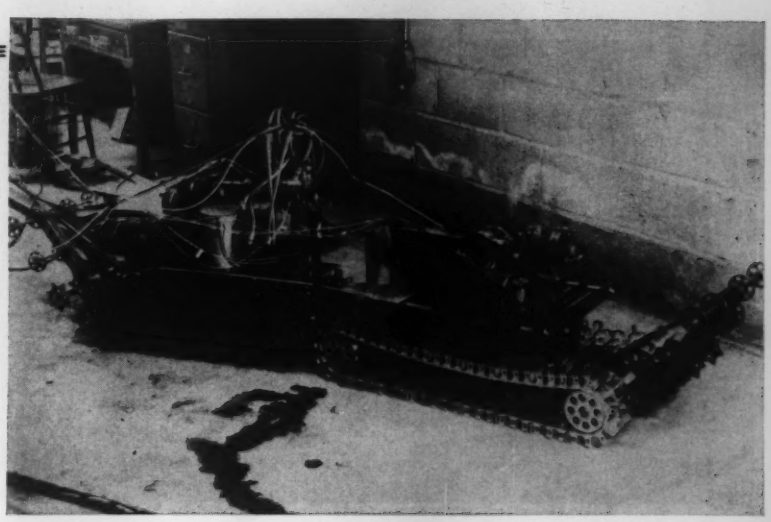
The tests performed since the introduction of crawler and rubber-tired vehicles have been inconclusive. They only proved that the solution is not detected by regular "cut and try" methods. What is needed is the establishment of a general method using applied mechanics to help design a land vehicle in the same way that fluid mechanics helps design ships and planes.

What should such a method consist of? It is basically the statement of soil-vehicle relationships by mathematical equations from which any desired performance parameter can be determined. Vehicle values (such as load, torque, speed, dimension, moment of inertia, etc.) have been well established, but soil values have not been considered. Any solution of the problem must start with measurement of soil.

This approach to the problem has led to the development of a new system of analysis that shows great promise in helping to improve the performance of off-the-road vehicles. Systematic work started with the establishment of the Land Locomotion Laboratory at the Ordnance Tank-Automotive Command.

The new method starts with construction of mathematical models of soil-vehicle relationships. These models are tested in the field and in the laboratory. After their utility is proved, their characteristics are programmed on a computer and desired parameters of performance are developed. From these parameters are determined the best weight, size and form of vehicle, tire size and load, inflation pressure, etc. Should a given area of operation contain conflicting requirements, operations research must determine the best compromise.

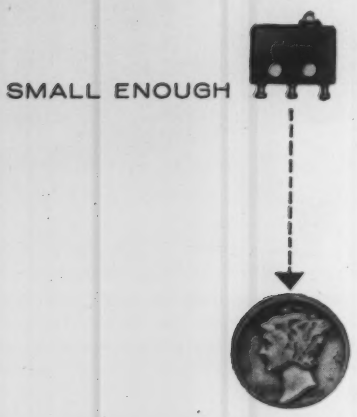
Up to now, any radical departure from well-established trends required the actual construction and field testing of a proposed vehicle. Since the cost and time involved is staggering, no one could afford to produce many experimental models of a radical design. Now, however, an evaluation of many vehicle concepts, in a large number of soils is feasible for comparatively little time and cost.



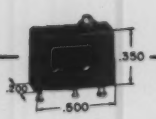
Scale models test spaced-link track and articulated-vehicle proposals before full-scale models are built. Parameters developed by Land Locomotion Laboratory permit extrapolation of results from these models to predict performance of full-scale vehicles.

Full-scale articulated vehicle with spaced-link track was built using information learned from soil tests. Its behavior was predicted from scale models before it was built.

MICRO SWITCH Precision Switches



Smallest of precision snap-action switches ... ½ kw capacity



CASE SIZE: .500″ x .200″ x .350″—ten to the square inch.

WEIGHT: 1 gram—28 switches to the ounce.

ELECTRICAL RATING: 28 vdc: 7a. resistive, 4 a. inductive—sea level; 2.5 a. inductive—50,000 ft.; 4 a. motor load, 2.5 a. lamp load, 24 a. max. inrush. 115/230 vac: 60 to 400 cycles: 5 a.; 15 a. inrush.

MECHANICAL LIFE is in the millions of operations.

The case of the 1SX1 has two through holes that accept #2 screws. One hole is slightly elongated to facilitate mounting.

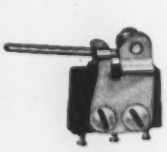
The 1SX1 operates dependably in temperatures from −65°F to +250°F. Operating force is controlled and predictable within 3 oz. to 5 oz. limits.

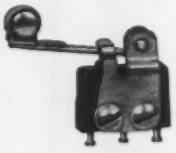
For more information about this important switch, ask for Catalog 63.

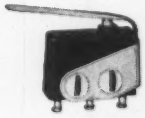
MICRO SWITCH field engineers will be glad to provide application assistance and give you full information on this sub-subminiature switch and its actuators. Call your nearby MICRO SWITCH branch office.

Now offered with six actuators

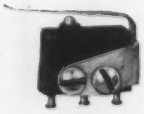
These actuators are offered in four basic designs and, in addition, two reversed actuators are offered which provide lower free position and reduced pre-travel.


Pivoted lever actuator


Pivoted roller lever actuator


Leaf actuator

Roller leaf actuator


Reverse leaf actuator

Reverse roller leaf actuator

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Progress in Pyroceram

. . . new material for high-temperature bearings

WILLIAM ROSENBERG
Chief Engineer
Universal Machine Co. Inc.
Baltimore, Md.

HIGH TEMPERATURES and high machinery speeds have imposed demands upon bearings that were almost unheard of a decade ago. To meet such challenges, new materials are constantly being evolved. One of the newest material developments, still in the experimental stage, is Pyroceram; in ball bearing form, it can operate at temperatures as high as 1500 F. Because it is easily fabricated, has high hardness, chemical stability, strength, and shock resistance, Pyroceram could become one of the more important bearing developments of recent years.

What Is It?

Pyroceram is a trade name for a crystalline ceramic produced by the New Products Div., Corning Glass Works, Corning, N. Y. It is developed from glass with crystallizing agents added to form a ceramic. The glass is melted, formed, cooled, and then reheated to the crystallizing temperature. This causes submicroscopic nuclei to precipitate and grow.

Two Types . . .
Custom-Tailored Properties

Properties	Type Grey	White
Physical		
Specific gravity at 25 C	2.60	2.50
Water absorption	none	none
Porosity	gastight	gastight
Mechanical		
Young's Modulus (psi x 10^{-6})	17.3	12.5
Poisson's Ratio	0.245	0.250
Rupture Modulus, abraided (psi x 10^{-3})	20.0	16-23
Hardness (Knoop-500 gm)	619	588
Thermal		
Softening temperature (C)	1250	1250
Specific heat at 25 C (cal/gm-C)	0.185	0.190
Mean specific heat 25-400 C	0.230	0.235
Thermal conductivity at 25 C (cal-C/cm sec x 10^{3})	8.7	4.7
Thermal expansion coefficient 25-300 C $^{\circ}$(cm/cm-C x 10^{7})	57	7-20*

*Depending on heat treatment.

Code 9606 (grey)
Initially developed for missile radomes. Has uniform electrical properties at microwave frequencies and elevated temperatures.

Code 9608 (white)
Developed as a general-purpose product. Shock resistance is so high that thin-walled tubing can be heated to 1300 F and immediately plunged into ice water without adverse effects.

Ball-Bearings: Wear vs. Temperature

Check for Compatibility

Before rolling tests (Table) were begun, preliminary evaluations of Pyroceram as a bearing material were conducted without lubrication at room temperature and at 1000 F. Both grey and white Pyroceram were caused to slide against themselves and against other high-temperature materials. Combinations of the other materials were also studied for comparative purposes.

Indications were that Pyroceram vs. Pyroceram was unsatisfactory, and that Pyroceram vs. metal was satisfactory with some metals. When ceramic slides against metal, metal transfers to the ceramic. Sliding then becomes essentially metal on metal. When Pyroceram slides against Pyroceram, high friction and wear occur, although surface damage is negligible. Wear, of course, can be reduced by use of suitable lubricants.

Room-Temperature Rolling

Metals that have a good past history of high-temperature rolling were extensively studied. Rolling characteristics of Pyroceram were investigated with a ball-and-raceway device which resembled a type of pivot bearing. It consisted of a ½-in. diam driver ball which was held in a chuck and rotated in contact with three ¼-in. diam balls free to roll in a cylindrical raceway. Width of the driver ball and track was the criterion for evaluating results.

Two types of loading were employed. A force of 4.2 kg on Pyroceram is equivalent stresswise to a 10 kg load on steel. This corresponds to a Hertzian stress of about 250,000 psi. The 10-kg studies are of little more than academic interest, since Pyroceram does not appear to be a likely substitute for steel in the span of temperatures where steel can be used. Room-temperature tests were included because every high-temperature bearing operates at some time or other at reduced temperatures.

At room temperature, the Pyroceram-Pyroceram-Pyroceram system was unsatisfactory, but both the Pyroceram-steel-Pyroceram and the steel-Pyroceram-steel systems were promising, indeed, they were almost as good as the steel-steel-tool steel system included for reference.

Materials			Load	Driven Balls Wear-Track Width
Driver Ball	Driven Ball	Raceway	(kg)	(mils)
1. At room temperature, lubricated with SAE 10 motor oil				
Pyroceram	Pyroceram	Pyroceram	4.2	13.75
52100 Steel	Pyroceram	M-2 Tool Steel	4.2	10.12
Pyroceram	52100 Steel	Pyroceram	4.2	<10
52100 Steel	52100 Steel	M-2 Tool Steel	4.2	5.17
Pyroceram	Pyroceram	Pyroceram	10.0	44.8
52100 Steel	52100 Steel	M-2 Tool Steel	10.0	10.12
2. At 700F, Unlubricated				
Pyroceram	Pyroceram	Pyroceram	4.2	40.5
M-1 Tool Steel	Pyroceram	M-2 Tool Steel	4.2	19.8
Al_2O_3	Al_2O_3	Pyroceram	4.2	24.3
M-1 Tool Steel	M-1 Tool Steel	M-2 Tool Steel	4.2	31.3
3. At 700F, lubricated with Triphenyl P-biphenyl silane				
Pyroceram	Pyroceram	Pyroceram	4.2	21.6
M-1 Tool Steel	Pyroceram	M-2 Tool Steel	4.2	17.82
Pyroceram	M-1 Tool Steel	Pyroceram	4.2	9.45
Pyroceram	Pyroceram	Pyroceram	10.0	56.7
M-1 Tool Steel	M-1 Tool Steel	M-2 Tool Steel	10.0	10.8
4. At 1200F, unlubricated				
Pyroceram	Pyroceram	Pyroceram	4.2	(high)
Pyroceram	Stellite 3	Pyroceram	4.2	23
Pyroceram	K-Monel	Pyroceram	4.2	(would not run)
Pyroceram	Hastelloy B	Pyroceram	4.2	33.6
Pyroceram	Hastelloy C	Pyroceram	4.2	12.0
Pyroceram	Hastelloy C	Pyroceram	10	27.5
Hastelloy C	Hastelloy C	Pyroceram	4.2	19.6
Pyroceram	Kentonium K161B	Pyroceram	4.2	11.3
Pyroceram	Kentonium K161B	Pyroceram	10	(track chipped)
Pyroceram	Kentonium K162B	Pyroceram	4.2	18.9
Pyroceram	Carboloy 608	Pyroceram	4.2	23.3

High-Temperature Rolling

The 700-F, unlubricated tests confirmed that the steel-Pyroceram-steel combination holds some promise. Unfortunately, one of the driven balls cracked after running for 15 min. This failure could have been caused by a defect in the ball. The Al_2O_3 run was included because aluminum oxide is one of the few materials which has proved to be comparatively impervious to high temperatures.

The 700-F, lubricated tests again point out both Pyroceram-steel-Pyroceram potentialities, and the incompatibility of Pyroceram-Pyroceram-Pyroceram.

At 1200 F, Pyroceram compatibility with both high-temperature alloys and with cemented carbides was studied. Here the Pyroceram, Hastelloy C, Pyroceram combination proved to be excellent, much

Remarks
Smooth tracks.
Smooth tracks.
Tracks indistinct.
Smooth, faint tracks.
Smooth tracks, high wear.
Smooth track.
Operating roughly; stopped after 1 min.
Ran 15 min; one driven ball failed.
Operating roughly; stopped after 8 min.
Operating roughly; ran 30 min.
Smooth track.
Deep, smooth wear track.
Minor wear with cracking and spalling.
Operating roughly; stopped after 15 min.
Smooth track, low-wear; ran 30 min.
Driven balls disintegrated after 4 min. Some metal transferred to Pyroceram; dark and fairly smooth film formed.
Skid marks; Monel badly damaged.
High wear, fairly smooth track; some material transferred to Pyroceram; Hastelloy B has glassy oxide film.
Smooth, light tan film on track; no transfer; Hastelloy C has glassy oxide film.
Smooth track on Pyroceram; Hastelloy balls have glassy oxide film.
Driver ball track has some depth, appears to be "worked"; fairly smooth.
Smooth, light tan film on track; no transfer; driven balls have smooth glassy film.
Pyroceram ball damaged; driven balls in fairly good shape.
Fairly smooth; some islands of built up material on Pyroceram track.
Very similar to results with K162B.

better than the reference system (Hastelloy C, Hastelloy C, Pyroceram). Other combinations gave results that varied from moderately successful to poor (with K-Monel). Among the carbides, Kentonium K161B and K162B both proved very compatible.

As the structure cools it changes to an opaque ceramic which is, technically speaking, heat-treated glass. This heat-treated glass is harder than the parent glass, and it possesses higher impact and abrasion resistance than the parent glass. It can be formed by conventional high-speed glass forming methods and therefore can be manufactured in a variety of sizes and shapes. In its initial state, prior to heat treatment, Pyroceram can be ground by standard glass-finishing methods, and precision grinding can easily be done in the crystalline state.

What Will It Do?

The most promising property of Pyroceram is its ability to retain hardness at temperatures between 1000 F and 1600 F. In this range, 52100 bearing steel will be cherry red and will bend with its own weight, but Pyroceram is unaffected, even in load-carrying ability. A bearing with this material used in the races will carry about 40 per cent of the load of a 52100 steel bearing. The steel bearing, of course, would be unusable at temperatures of even 800 F for any prolonged period.

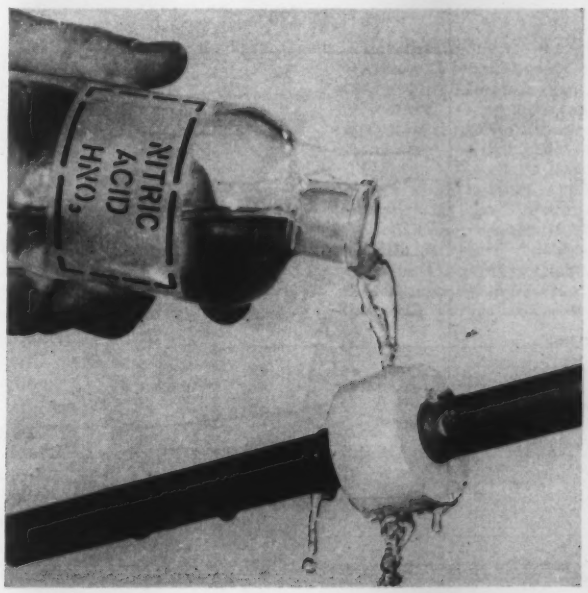
Another quality which gives this material real potential is its chemical inertness. Except for those reagents which are used to etch glass, nothing in the line of ordinary industrial chemical reagents affects Pyroceram, even at elevated temperatures. This suggests the possibility of a major breakthrough in processing industries where corrosive atmospheres coupled with high operating temperatures have presented an almost insurmountable barrier to the operational longevity of bearings and seals.

What's Being Done?

Experiments are currently being conducted with two types of this high-temperature ceramic. These, designated Code 9606 and Code 9608, are gray and white Pyroceram, respectively.

Corning and some of the leading antifriction bearing manufacturers are presently investigating various possibilities of this material. At this time, it is too soon to say how much can be done toward realizing mass production of high - temperature bearings or high-temperature seals.

Because of its qualifications for high-temperature operation and its exceptional chemical stability at elevated temperatures, Pyroceram is a likely choice for bearings exposed to corrosive fluids. In such applications,



Pyroceram remains unaffected when exposed to corrosive fluids. Further, a Pyroceram bearing when coupled with stainless steel (304), Hastelloy B, or even when coupled with another Pyroceram bearing, exhibits only negligible wear when most of these fluids are used as bearing lubricants.

it could conceivably fill the dual role of bearing and seal.

Some tests have been run to determine sliding characteristics of this new ceramic—in combination with itself and with other materials—under immersion conditions with corrosive fluids. Combinations of materials were run in salt water, ferric chloride, citric acid, sodium hydroxide, nitric acid, hydrogen peroxide, and molten lead. Surface damage was generally negligible to the ceramic compound, and results indicated that Pyroceram sliding against itself gave less damage than Pyroceram sliding against metals.

Tests performed to date indicate Pyroceram could be the answer to many bearing problems. Some manufacturers are already producing certain sizes to order. One company is now accepting orders for bearings with Pyroceram races and Stellite balls. It should be obvious, however, that all data must be regarded as preliminary. Investigations also make it appear that antifriction bearings with Pyroceram races, high-temperature steel balls, and retainers of heat-resistant material would make satisfactory elevated-temperature bearings.

What's Next?

Because the highest friction in a ball bearing is developed between the balls and the retainer, problems presented by retainer materials will probably be most difficult. Pyroceram bearings are being produced now with Monel retainers and with carbon retainers, but both these materials have limitations. There are materials other than those tested which should not be overlooked in the search for the ultimate in ball and/or race compounds. In the field of hard refractories, for example, two materials with high-temperature properties appear to be worthy of further investigation: Columbium carbide and vanadium carbide. The Battelle Memorial Institute is presently testing such materials as coatings for nuclear tubing. Both have melting points above 5000 F and hardnesses in the range of tungsten carbide.

Obviously, preliminary data must be rechecked to determine reproduciblity. Stop-and-start cycling investigations will probably be undertaken for both journal and ball-bearing conditions. Oscillating bearings will also be studied, for such tests should simulate the worst conditions under which bearings can be used.

It must be emphasized that materials such as Pyroceram are now being evolved because of the relatively new limitations to the more conventional metallic materials. Therefore, it would be incorrect at this time to think of such new materials as a blanket replacement for steel, for example. These new compounds, however, could become as important in future applications as our well-known alloys are at present.

Journal Bearings: Time and Temperature Effects

Test Notes

[1]Shaft seized after 4 min operation.

[2]Operated smoothly.

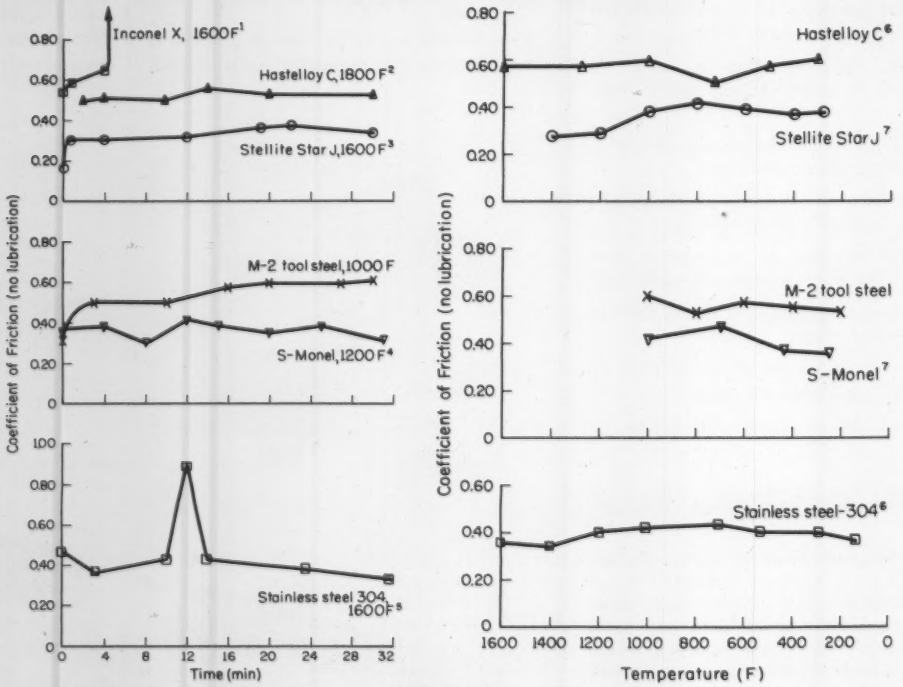
[3]Light continuous chatter in the final portion of the run.

[4]Intermittent squeaking.

[5]Very quiet for first ten min; noise increased as friction increased, decreased as friction decreased.

[6]Seizure occurred at room temperature.

[7]No seizure, even when operated at room temperature.



Hoover announces 3L00 extra light bearings

Now, America's quality bearings come in compact proportions designed to save space! Hoover's new 3L00 series extra light ball bearings provide the solution to bearing problems calling for maximum bore size and minimum housing area. They have outer diameter and width dimensions that are substantially smaller than those of standard light, medium or heavy series bearings of equal bore size.

Hoover 3L00 extra light ball bearings are available in a wide range of popular sizes in open, shielded and sealed types, including lubricated-for-life bearings with Hoover-developed contact seals of TEFLON. For complete information, return the coupon below.

Hoover quality is outstanding!

Micro-Velvet balls are made of selected high-carbon chrome alloy steel, uniformly hardened, and finished so perfectly that roundness and diameter are accurate within millionths of an inch.

Hoover Honed raceways, on both inner and outer rings, are super-smooth, superbly finished. Precision matching of ball complements and raceways assures hushed quietness, long life, superior Hoover performance.

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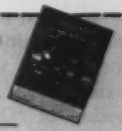
Hoover Ball and Bearing Company MD-8
5400 South State Road, Ann Arbor, Michigan

Please send new Bulletin 108, which describes Hoover 3L00 extra light bearings.



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Company_____

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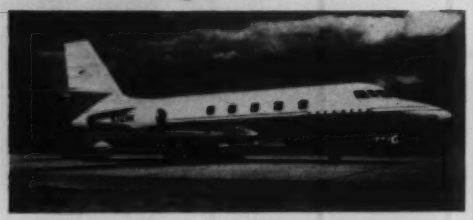
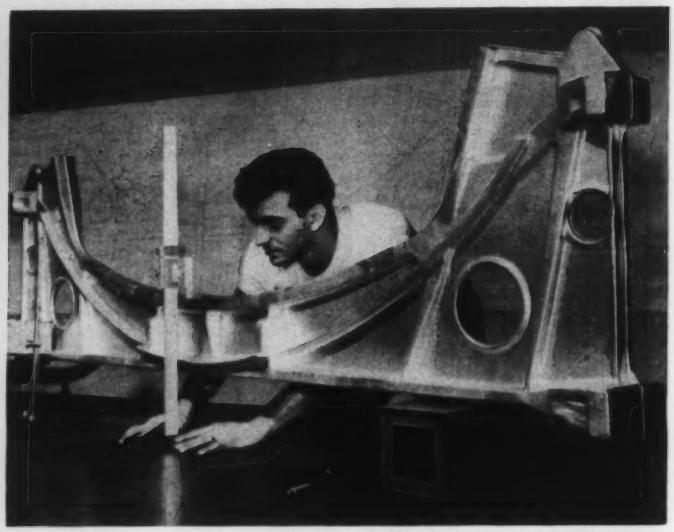
Bolt-On Wings Slim Jetstar Profile





Fresh approach to an old fabricating problem gives Lockheed's Jetstar a big boost in performance. Designers of the craft devised a method of attaching the wing externally, rather than extending a bulky structure through the fuselage. This has narrowed fuselage diameter by 12 in. and cut drag substantially. Key structural members are aluminum forgings 85 in. long and up to 4 in. thick. Five of the deeply curved parts, produced by Alcoa, span the fuselage between wing roots. Top and bottom wing surfaces bolt directly to each forging at its juncture with the fuselage skin. Engines attach to rear fuselage.

Fabric Fire-Walls Seal Off "Hustler" Wings

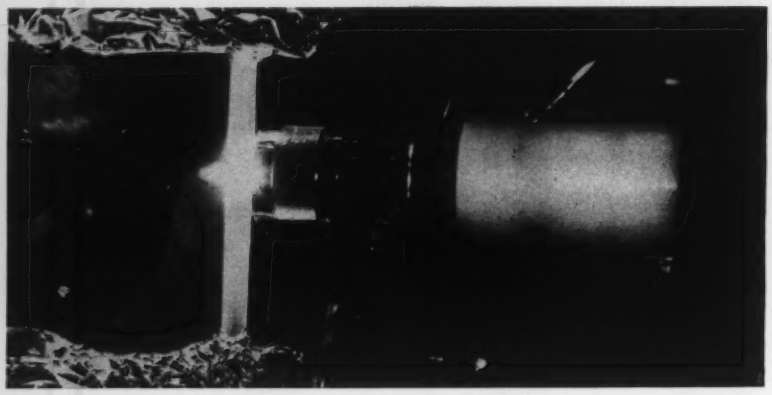
WILMINGTON, DEL.—A new fabric with better heat and flame resistance than stainless steel is one material that meets the stepped-up requirements of America's "hottest" jet bomber, the Convair B-58. The material—an asbestos-base fabric coated with a new synthetic rubber (Viton) and reinforced with Inconel wire—provides fire-wall seals in the supersonic aircraft.

To qualify for the job, the material had to prove itself resistant to damage by oils, greases, and jet fuels, and be nonabsorbent to volatile fuels, even at temperatures of 500 F. Also, it had to be easily fabricated and flexible so that close-fitting units could be worked into out-of-the-way corners.

Resistance of Viton to heat, chemicals, jet fuels, and solvents is in a range completely new in the elastomer field. With the 1800-F flame of a gun-type oil burner directed against the fabric while an exhaust fan maintained negative pressure on the reverse side, tests indicated no flame penetration or failure over a period of 60 minutes. In addition, there was no glow on the side of the material away from the flame. This is in marked contrast to previous tests of conventional materials, all of which have a tendency to glow on the back and generate large quantities of smoke.

Further test results indicate the new fabric does not crack on flexing, even at temperatures as low as −40 F and as high as 500 F, and is not weakened by corrosive fluids or commercial fuels. In addition, the fabric showed marked improvement over other materials from the point of view of absorption of fluids and swell on exposure to oils.

Development of the product is credited to engineers of Raybestos-Manhattan's General Asbestos and Rubber Div., Passaic, N. J.; development of Viton synthetic rubber was by E. I. du Pont de Nemours & Co.



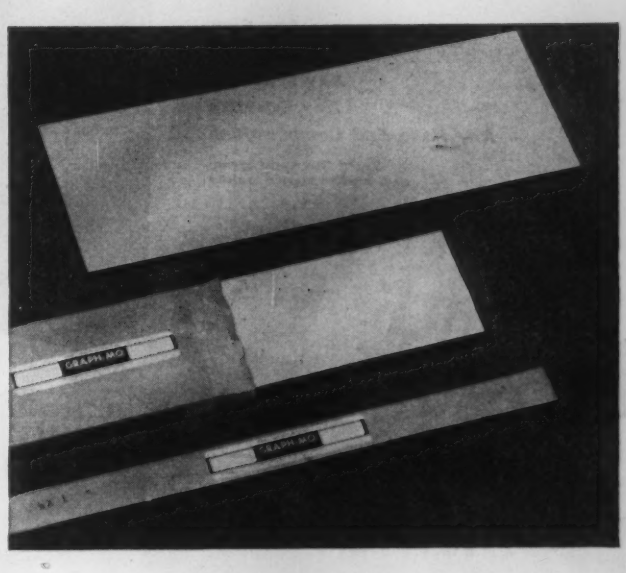
Plasma on a Budget

Small plasma generator developed by Avco Research and Advanced Development Div., Wilmington, Mass., is announced as the first inexpensive laboratory tool available to industry for generating temperatures from 2500 to 12,000 F. It operates from a standard welding generator, and can be fired into either a vacuum or pressure chamber without major modification. Avco uses an ultrasonic pulse system to measure temperature of the plasma jet. Quartz probes (photo) extend into the flame to transmit and receive sound pulses which are converted into temperature measurements. The plasma generator is one of a family being developed by Avco for industrial and laboratory use.

New economy for tool steel users . . .

FAMOUS GRAPH-MO® NOW AVAILABLE IN PRECISION GROUND FLATS

. . . from 41 distributors in 33 cities



Now you can get precision ground flats with all the advantages of the Timken Company's famous Graph-Mo® tool steel. They're available through the conveniently located distributors listed below. You get all these advantages: *Semifinished* . . . saving preliminary machining operations. *Graph-Mo outwears ordinary tool steels 3 to 1* because of the combination of free graphite particles and diamond hard carbides in its structure. *Machines 30% easier* than conventional tool steels. *Uniform response to heat treatment* eliminates distortion. *Specially wrapped* in protective envelopes carrying heat-treating information. *And there are 250 sizes* of flats to choose from.

Get your stock list from our distributors or by writing direct. There is only *one* Graph-Mo, and the Timken Company makes it. The Timken Roller Bearing Company, Canton 6, Ohio. Cable address: "TIMROSCO". *Makers of Tapered Roller Bearings, Fine Alloy Steels and Removable Rock Bits.*

DISTRIBUTORS OF TIMKEN GRAPHITIC TOOL STEELS

ALABAMA
Birmingham—O'Neal Steel, Inc.

CALIFORNIA
Los Angeles—Coulter Steel & Forge Co.
Los Angeles—Earle M. Jorgensen Co.
Oakland—Coulter Steel & Forge Co. (Emeryville)
Oakland—Earle M. Jorgensen Co.
San Francisco—A. Milne & Co., Inc.

GEORGIA
Atlanta—A. Milne & Co., Inc.
Atlanta—O'Neal Steel, Inc.

ILLINOIS
Melrose Park—A. Milne & Co., Inc.
Chicago—The Peninsular Steel Company

INDIANA
Indianapolis—The Peninsular Steel Co.

MASSACHUSETTS
Boston—A. Milne & Co., Inc.

MICHIGAN
Detroit—Alloy Steels, Inc.
Detroit—A. Milne & Co., Inc.
Detroit—The Peninsular Steel Company
Grand Rapids—The Peninsular Steel Co.

MISSISSIPPI
Jackson—O'Neal Steel, Inc.

MISSOURI
St. Louis—Ford Steel Company

NEW JERSEY
Kenilworth—A. Milne & Co., Inc.

NEW YORK
Buffalo—The Peninsular Steel Company (Tonawanda)
New York City—A. Milne & Co., Inc.

OHIO
Akron—The Peninsular Steel Company
Cleveland—A. Milne & Co., Inc.
Cleveland—The Peninsular Steel Co.
Dayton—A. Milne & Co., Inc.
Dayton—The Peninsular Steel Company
Dayton—Alloy Steels, Inc.
Toledo—The Peninsular Steel Company

OKLAHOMA
Tulsa—Earle M. Jorgensen Co.

OREGON
Portland—Pacific Machinery and Tool Steel Co.

PENNSYLVANIA
Philadelphia—A. Milne & Co., Inc.
Pittsburgh—A. Milne & Co., Inc.

TENNESSEE
Chattanooga—O'Neal Steel, Inc.

TEXAS
Dallas—Earle M. Jorgensen Co.
Houston—Earle M. Jorgensen Co.

UTAH
Salt Lake City—Coulter Steel & Forge Co.

WASHINGTON
Seattle—Coulter Steel & Forge Co.

CANADA
London, Ont.—Vanadium-Alloys Steel Canada Ltd.
Montreal, Que.—Vanadium-Alloys Steel Canada Ltd.
Toronto, Ont.—Vanadium-Alloys Steel Canada Ltd.

TIMKEN® *Fine Alloy* STEEL

SPECIALISTS IN FINE ALLOY STEELS GRAPHITIC TOOL STEELS AND SEAMLESS STEEL TUBING

STANDARD HOSES

LOW PRESSURE

H-9 — SAE 30R2

H-100 — COTTON COVERED

MEDIUM PRESSURE

H-17 — SAE 100R3

HIGH PRESSURE

H-25 — SAE 100R2

MEDIUM HIGH PRESSURE

H-69 — SAE 100R5

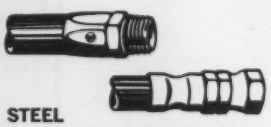
MEDIUM HIGH PRESSURE

H-108 — SAE 100R1

HIGH PRESSURE

H-35, H-50 — Spiral Wire Reinforced

REUSABLE ENDS



STEEL

STANDARD 2-PC. END

For fast assembly and positive, leakproof connections. Designed for dependable performance under high pressure. Skive and no-skive.

CLAMP-TYPE

For most two-wire braid high-pressure hydraulic hose applications. No skiving of hose or special tools required.

BARB-TITE ENDS

Fast, easy push-on, stay-on hose ends for all types of low pressure applications. Sizes ¼" to ¾" I.D. Rugged and durable.

HOSE ASSEMBLIES

PERMANENTLY ATTACHED HOSE ENDS

Swaged or crimped permanently attached hose ends. Any quantity, any size, any type. ⅛" to 2". For all working pressures.

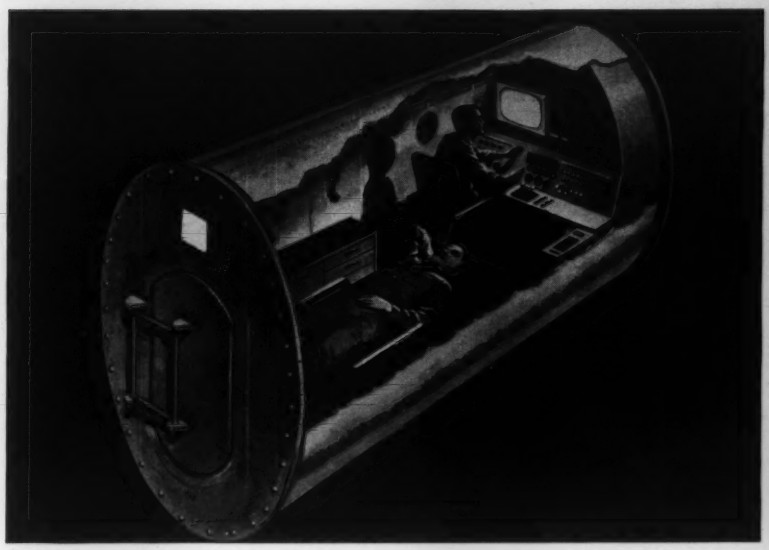
CRIMPED

SWAGED

TUBE-HOSE ASSEMBLIES

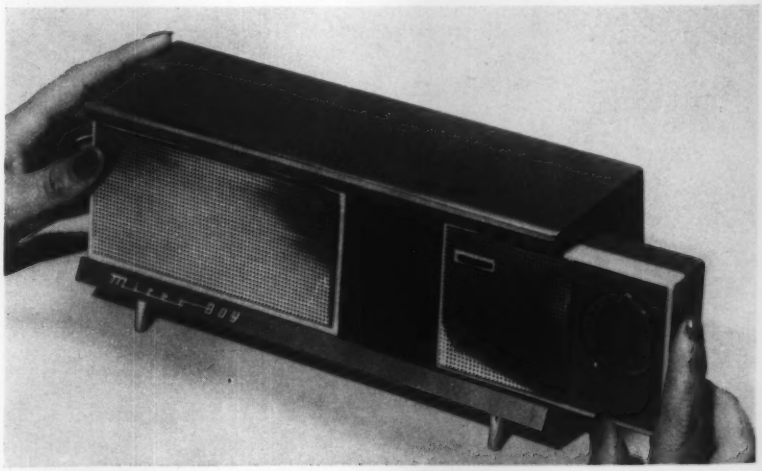
THE WEATHERHEAD COMPANY

FORT WAYNE DIVISION • Dept. MD8, 128 West Washington Blvd.
Fort Wayne, Indiana



Simulated Space Suite

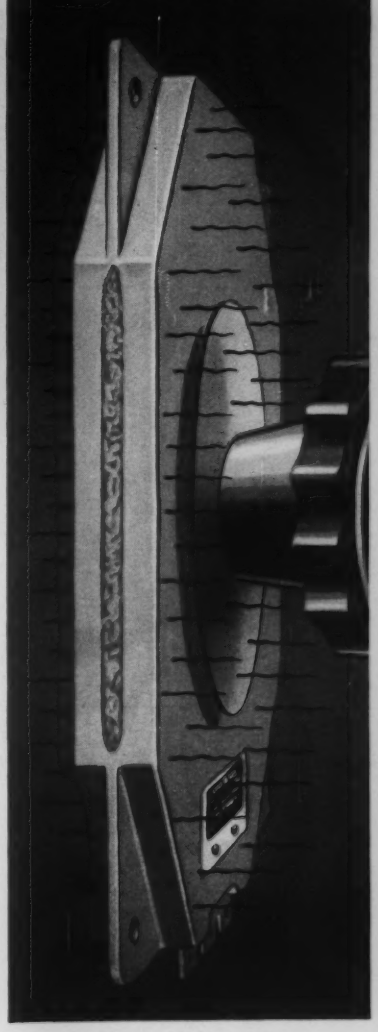
Seven-ton capsule designed to house two men is the newest test tool in man's conquest of space. In this "world's smallest efficiency apartment" two Air Force men will soon go on a 30-day simulated space flight. Being built by Minneapolis-Honeywell Regulator Co., Minneapolis, for the Air Force School of Aviation Medicine, the capsule is an elliptical steel tank 8-ft. high by 12-ft long. It will be equipped with all the necessities of life, and as many comforts as possible—including recorded music and a high-voltage electrostatic filter to incinerate cigarette smoke. The two occupants will be observed through closed-circuit TV and one-way glass observation ports in the sides of the cabin. Test instruments will record environmental conditions and other data over the 30-day period.



Portable Radio Converts to Console

Take-apart design gives big-speaker performance from a German portable radio. The radio neatly fits into the speaker housing, which then appears to be a regular home radio. Built-in jacks automatically disconnect the portable's speaker as soon as the larger speaker is turned on—thereby improving reproduction quality of the unit. The transistorized radio operates from a 9-v dry-cell battery and uses printed circuits and a ferrite antenna to cover the medium wave band. The radio weighs less than 11 oz and measures only 4½ by 3 by 1¼ in. The unit was designed and developed by Grundig Radio-Werk GmbH, Fuerth/Bay, Germany.

PLATE-TYPE
RHEOSTATS



DISSIPATE HEAT FROM BOTH SIDES

Greater, two-side heat dissipation means you can use a smaller, lower-cost rheostat for a given rating. G-E rheostats are metal-encased and cement filled to dissipate heat from both sides and increase watt capacity. See how you can benefit from greater heat dissipation; follow reader service instructions below. General Electric Company, Roanoke, Virginia. 784-21

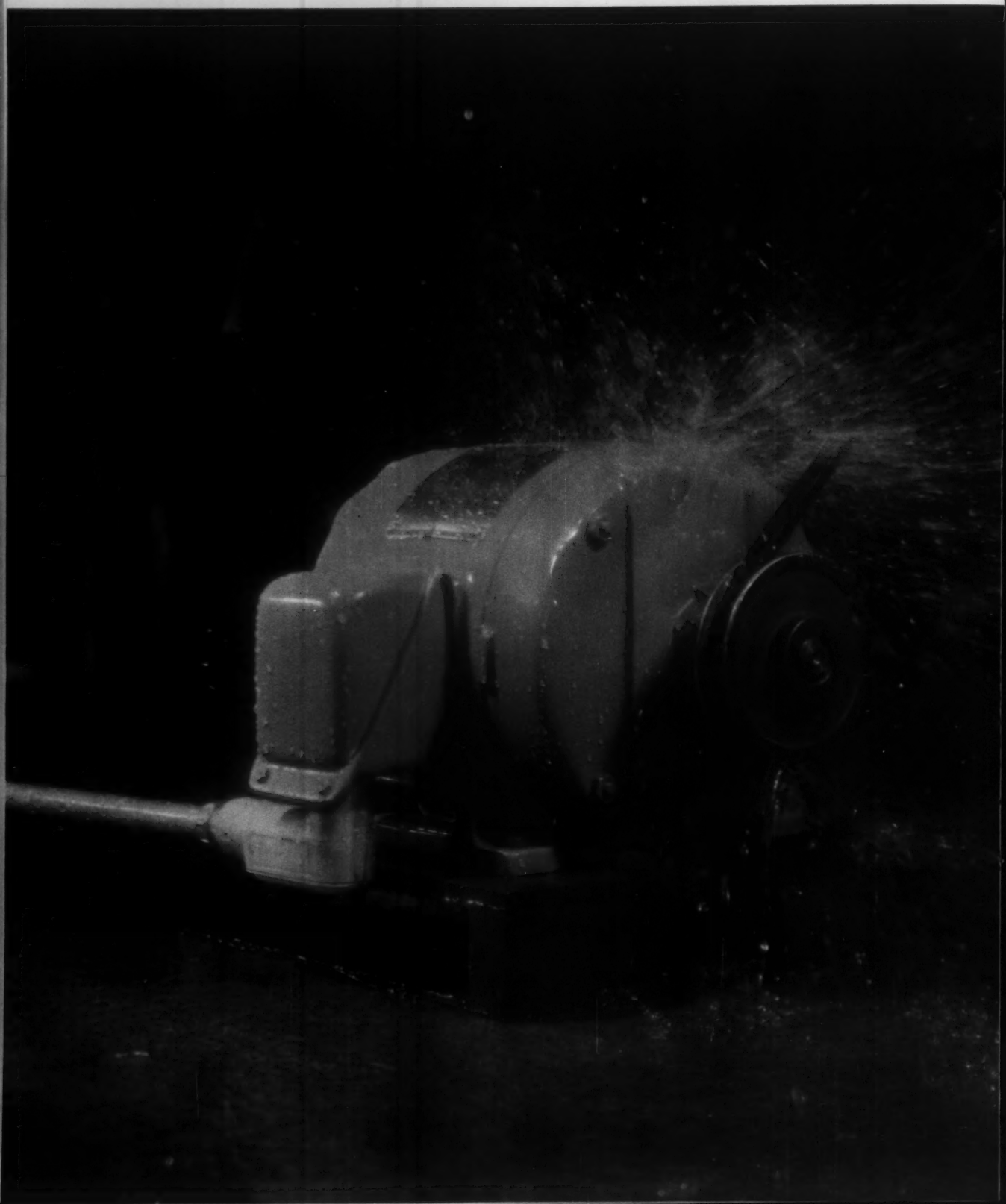
Progress Is Our Most Important Product

GENERAL ELECTRIC

Circle 418 on Page 19

Circle 419 on Page 19→

Get dependable operation, increased



quality for your product . . .

GENERAL ELECTRIC TRI 55 CLAD MOTORS PROVE THEY PROVIDE IT BY PASSING TORTURE TEST

HERE'S HOW: G-E Tri/Clad '55' polyphase motors are more fully enclosed than ordinary dripproof motors. This extra protection makes them suitable for many jobs which normally require splashproof motors . . . extra protection at no extra cost.

Mylar* polyester film slot and phase insulation, non-wicking leads, and water-resistant stator coating give long-life protection against *moisture.* Formex† magnet wire provides protection against heat-aging and *dirt.* Heavy-duty bearing system keeps lubricant in, abrasive dust out. And rigid cast-iron frame and endshields and melamine paint finish protect G-E motors against *external damage.*

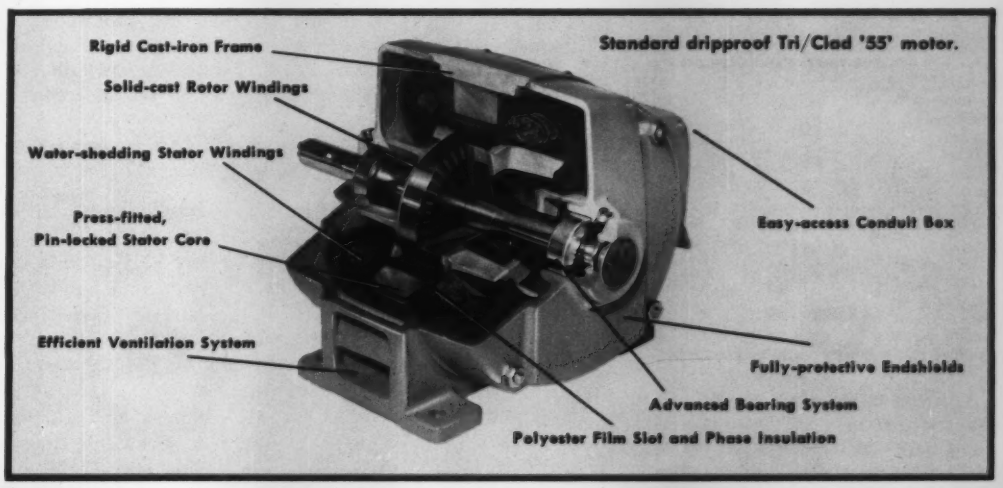
*Registered Trade-mark of DuPont Co.

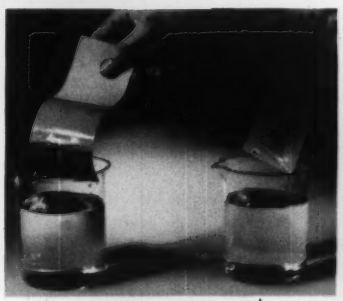
These are just some of the outstanding Tri/Clad '55' motor features which mean longer life, more dependable operation—improve the quality and saleability of your product at no extra cost to you *or* your customers!

CONTACT your nearest G-E Apparatus Sales Office for *personal proof* on how G-E Tri/Clad '55' motors can give better operating protection to your products. And ask for your free copy of descriptive bulletins, GEA-5980 and GEA-6602, or write to Section 840-19, General Electric Company, Schenectady 5, New York.

†Registered Trade-mark of General Electric Co.

GENERAL ELECTRIC

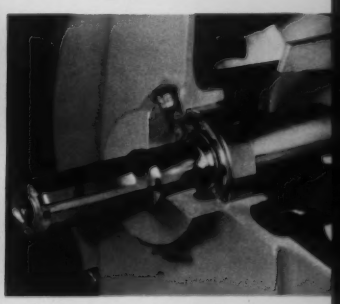




Mylar Insulation protects against moisture; assures longer motor life, minimum maintenance.

Water-resistant Coating applied to every stator assembly virtually eliminates insulation failure due to moisture.

Formex Wire insulation will not break under severe conditions—protects against heat-aging and abrasive dust.



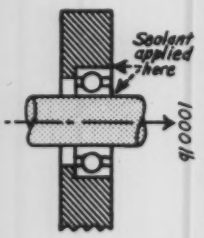
Long-life Bearing System seals dirt out, has new longer-lasting grease, can be regreased.

Edwin F. Oblinger, Chief Engineer, Parker Sweeper Company, says:

"WE THREW OUT PRESS FITS FOR BEARINGS..."

"We used interference fits to prevent bearing races from turning in the gear box of our 4HP Turbosweeper. Maintaining close tolerances was a constant headache. If the fit was loose, the race would slip and fret the surfaces; if the fit was tight, the race would deform and bearing life would be shortened. Then we discovered LOCTITE Liquid Sealant would do away with the need for press fits. We opened up the tolerances for both shaft and housing and used a slip fit, filling the clearance with LOCTITE. The bearings are retained with a force equal to the customary interference fit, but we've reduced rejected parts from 8% to less than 1% and reworked parts fell from 20% to 0! Field reports are excellent."

LIQUID SEALANT ... replaced interference fits and opened up tolerances almost 0.002 in. on shaft and housing for this ball bearing assembly. Load of over 1000 lbs. is needed to break bond.



LOCTITE is a penetrating liquid that hardens only after being confined between closely fitted metal parts. In the absence of air, the sealant hardens into a strong, heat and oil-resistant bond. The hardening action may be accelerated by heating.

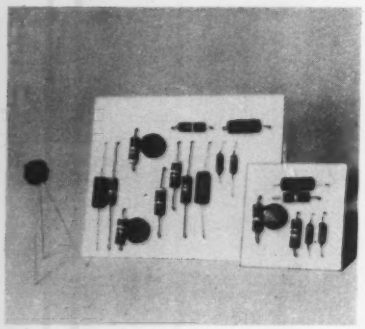
LOCTITE eliminates the need for interference fits on bearings, sleeves, shafts and studs ... locks nuts to bolts, seals pipe and tubing joints. For literature and free sample, write to:

LOCTITE® SEALANT

AMERICAN SEALANTS COMPANY
111 Woodbine St., Hartford 6, Conn.
Stocked by bearing and industrial distributors.

Circle 420 on Page 19

Solid State for Flip-Flop



Semiconductor switching device, called Trigistor, takes the place of two transistors in flip-flop circuits. A low-level positive pulse to the base turns it on. It remains on without further control until a low-level negative pulse to the base turns it off. Typical flip-flop circuit layout using Trigistor is shown in right foreground. Larger layout behind it uses two transistors to do the same job. Solid State Products, Inc., Salem, Mass., rates collector current in 1 to 8 ma range at up to 60 v. Turn-on time is 0.4 microseconds; standard types repeat at the rate of 50 kc, and a special version will repeat at 200 kc.

Dept. of Interservice Co-operation: Bouquets for Rickover

In recent testimony before Congress, Vice Admiral J. T. Hayward, Ass't Chief of Naval Operations (R & D), was asked to comment on the Air Force's Nuclear Airplane budget. The Admiral replied that the total sum spent to date is about what the Navy spent in developing nuclear submarines.

The difference, according to the Admiral, is that, for the same money, the Navy has purchased all research and development, paid all the fuel costs, built the facilities and prototypes, and delivered three operational submarines to the fleet.

He continued: "Of course, I attribute this directly to Admiral Rickover's position that he was going to get an engine before he got any sort of system."

In the discussion following, this banter took place between the Admiral and Congressman Daniel J. Flood (D., Pa.).

MR. FLOOD: If the gentleman will yield further, in what is Adm. Rickover an expert?

ADM. HAYWARD: Nuclear propulsion.

MR. FLOOD: Then why don't you have him figure out nuclear propulsion for an aircraft?

ADM. HAYWARD: Mr. Flood, he has 33 ships. We have plenty to do in the ship business. The last person I want to get mixed up in taking over the job is Adm. Rickover.

MR. FLOOD: I asked the Air Force that, and they said they would take him tomorrow morning and be glad to have him.

ADM. HAYWARD: I am not so sure.

MR. FLOOD: I am telling you what they told me.

ADM. HAYWARD: It would be an excellent idea.

MR. FLOOD: If he did as much for the Air Force as he did for the Navy, I hope he goes tonight.

ADM. HAYWARD: I do not want to say that aircraft nuclear propulsion is the end-all in military systems. It has great military potential.

MR. FLOOD: Nobody suggests that it is.

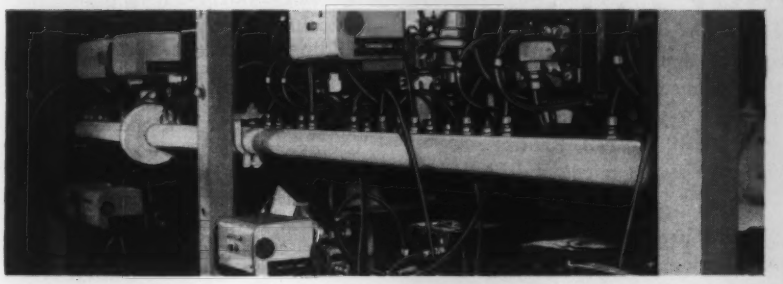
ADM. HAYWARD: I do not want to give away Adm. Rickover, Mr. Flood. We need him.

MR. FLOOD: No. I am trying to give him to the air arm of the Navy. They seem to be bogged down in the nuclear propulsion mechanics hardware. This man seems to be more than a black-shoe sailor. If the first things come first, it is how do you push that crate? I do not care what kind of crate it is, whether it is a ship in the air or a ship in the water. If this character Rickover can push it on and under the water, as far as I am concerned he can push it in the air.

IMPERIAL Engineering and Data File

ENGINEERED TUBE FITTINGS — VALVES — TUBING TOOLS

How Poly-Flo tube fittings cut installation costs, save space, eliminate bending



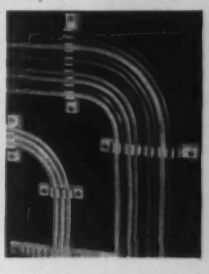
IMPERIAL'S Poly-Flo Fitting and Tubing now offer creative engineers a practical, low-cost solution to a wide range of tough jobs. The following case histories demonstrate typical Imperial product savings:

PROBLEM No. 1: High installation cost. Copper tubing cost $2.10 per ft. to install on an instrument panel for one Eastern Chemical plant. Further, chemical corrosion created high replacement costs.

SOLUTION No. 1: For an identical panel where polyethylene tubing and Poly-Flo Fittings were used, labor costs were slashed to 14½¢ a foot . . . a savings of 93%. Poly-Flo Tubing is also impervious to most chemicals, creating extra savings.

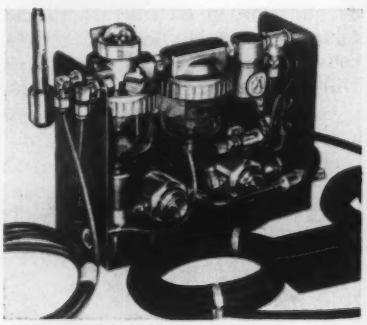
Sensational savings in time and labor — as with this documented example — are typical when you choose Poly-Flo. Remember, you need only a pocket knife to cut the tubing to exact length.

IMPERIAL also markets a unique plastic tube rack which speeds installation time when you're working with Poly-Flo tubing. This rack can be cut quickly to hold from 1 to 10 tubes. Furnished in natural polyethylene.



Find out more about the advantages of Imperial Poly-Flo Fittings and Tubing. Write today for Engineering File 3025.

When your application calls for fluid control valves . . . check on IMPERIAL's line of quality valves. Whether your Poly-Flo application calls for needle valves, toggle valves, 2-, 3-, or 4-way plug valves, or diaphragm valves, IMPERIAL manufactures just what you need. Write today for Imperial's Industrial Catalog No. 200.

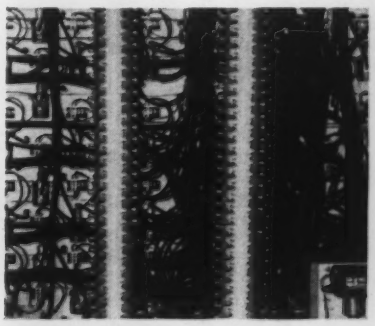


PROBLEM No. 2: Limited work space was encountered in assembling this dental equipment, designed by Aero Turbex. This equipment operates at speeds in excess of 250,000 rpm.

SOLUTION No. 2: Poly-Flo Tubing and Fittings beat this problem because no wrenches are needed for installation. Nut is just finger tightened, providing a connection that withstands the burst pressure of the Poly-Flo Tubing—from 250 to 600 psi.

Even in extremely close quarters **if you can reach the area with your fingers, you can make a foolproof connection.**

Tubing can be used in a temperature range from −90° to +175° F. Also, Poly-Flo is non-toxic, odorless and tasteless, an important consideration on food and medical equipment.

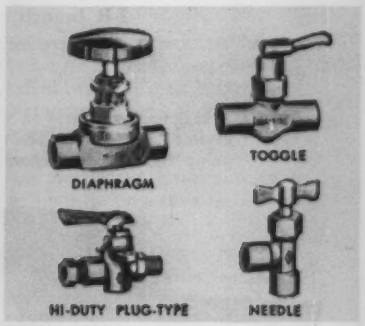


PROBLEM No. 3: Elimination of Tube Bending. Shown above is a Pressure Comparator Cabinet for an automatic data logging system. Because hundreds of tube bends were needed to complete the job, metal tubing costs were unduly high.

SOLUTION No. 3: Poly-Flo is so flexible, no time is wasted bending the tubing to fit. Tubing bends readily by hand. No special tools, either.

This tubing is ideal for smallest areas, too. For example, ¼" Poly-Flo tubing can be bent a full 360° to form a ⅞" radius circle *with no apparent constriction or collapsing of tube walls.*

Tubing is available in nine colors — color coding quickly identifies circuits. Sizes of tubing are: ¼" O.D., .040" wall; 5/16" O.D., .062" wall; ⅜" O.D., .062" wall; and ½" O.D., .062" wall.



THE IMPERIAL BRASS MFG. CO.
6300 W. Howard St., Chicago 48, Ill.
In Canada: 18 Hook Ave., Toronto, Ontario

IMPERIAL

FIRST NAME IN FLUID TRANSMISSION COMPONENTS

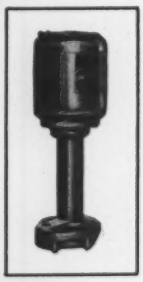
Circle 421 on Page 19

machinery builders
specify
MOTORPUMPS
for low-cost
efficiency . . . .

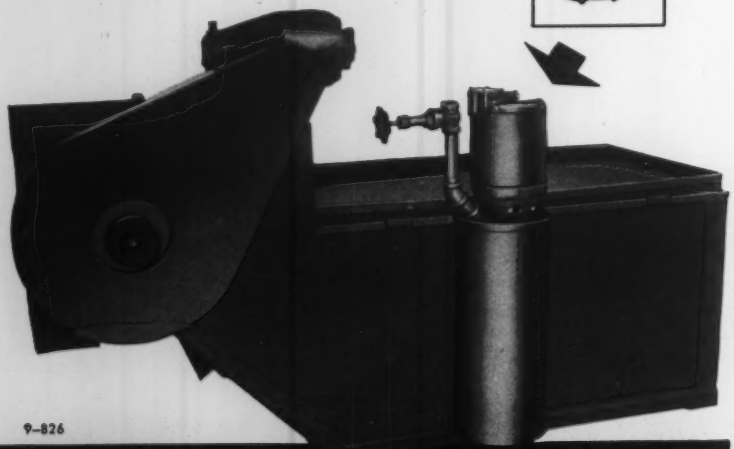
Their long record of dependability and efficiency . . . their many design features . . . their adaptability to many types of machines, has proved that Ingersoll-Rand Motorpumps offer advantages not found in any other pump.

Whatever your liquid handling requirements, there is a Motorpump that can meet your needs exactly. Select from the widest range of types, sizes and mountings available anywhere. You can save important time and money because Motorpumps are designed for easy adaptability to most equipment.

Why not consult with a thoroughly trained Ingersoll-Rand pump specialist who can help you with your liquid moving problem. Call your nearest I-R branch office or write for complete information.



A magnetic separator in which an Ingersoll-Rand immersion type Motorpump has been incorporated.



9-826

Ingersoll-Rand 11 Broadway, New York 4, N. Y.

Electronic Brain Zeroes In On Thinking Sub's Target

Alternate Control Station Double Checks Compact System

GREAT NECK, N. Y.—First sub to be fitted with the Mark 112 Torpedo Fire Control System, developed by Sperry Gyroscope Co., is the Polaris-launching *George Washington*, according to a recent Navy-announcement. The system incorporates a transistorized computer that takes radar or sonar information on an enemy ship's position, direction, and speed and solves a complicated geometric problem for aiming directions. Torpedoes with acoustic heads can be activated to search out enemy ships after they are a safe distance from the mother ship.

An Attack Console in the sub's attack center coordinates operations of all torpedoes on board. In an emergency, a Torpedo Control Unit in the torpedo room checks the Attack Console for errors and can assume command of torpedo firing.

The Sperry system, which weighs about half as much as conventional torpedo fire-control systems, has low power consumption, can be operated by one man in an emergency, and takes considerably less space than conventional systems. Eventually it will be installed on all nuclear subs.

Meetings and Shows

Sept. 7-11—

Illuminating Engineering Society. Annual National Conference to be held at the Fairmont and Mark Hopkins Hotels, San Francisco. Further information can be obtained from IES headquarters, 1860 Broadway, New York 23, N. Y.

Sept. 9-11—

American Society of Mechanical Engineers. West Coast Conference of Applied Mechanics, sponsored by the Applied Mechanics Div. of ASME in conjunction with the American Society of Civil Engineers, to be held at Stanford University, Stanford, Calif. Further

information is available from Meetings Dept., ASME, 29 W. 39th St., New York 18, N. Y.

Sept. 14-17—

Society of Automotive Engineers Inc. National Farm, Construction, and Industrial Machinery Meeting (including production forum and engineering display) to be held at the Milwaukee Auditorium, Milwaukee. Further information is available from SAE, 485 Lexington Ave., New York 17, N. Y.

Sept. 16-17—

American Die Casting Institute. Annual Meeting of the Institute and its research arm, the Die Casting Research Foundation, to be held at the Edgewater Beach Hotel, Chicago. Additional information is available from institute headquarters, 366 Madison Ave., New York 17, N. Y.

Sept. 17-18—

American Society of Mechanical Engineers — American Institute of Electrical Engineers. Engineering Management Conference to be held at the Statler Hilton Hotel, Los Angeles. Additional information is available from Meetings Dept., ASME, 29 W. 39th St., New York 18, N. Y.

Sept. 18—

Malleable Founders Society. Industry Meeting to be held at Hotel Sheraton-Cleveland, Cleveland. Additional information is available from society headquarters, 781 Union Commerce Bldg., Cleveland 14, Ohio.

Sept. 20-23—

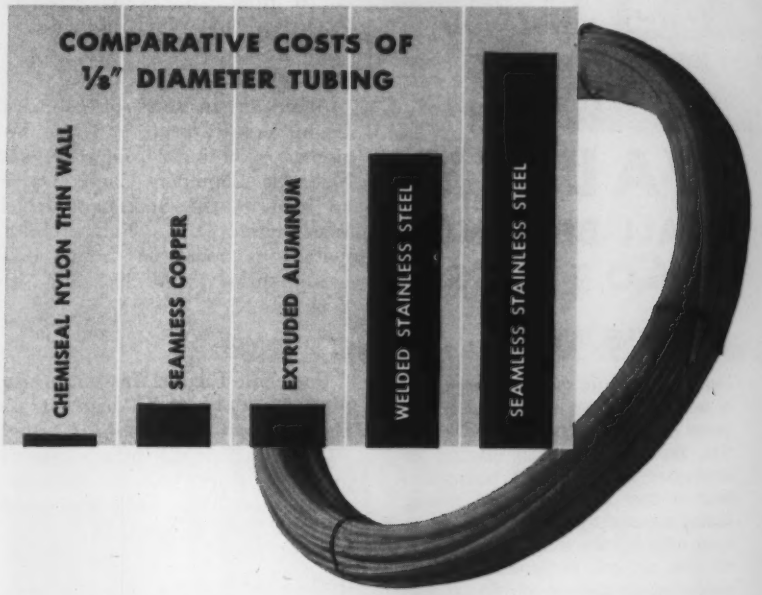
American Society of Mechanical Engineers. Petroleum Mechanical Engineering Conference to be held at the Rice Hotel, Houston. Further information is available from Meetings Dept., ASME, 29 W. 39th St., New York 18, N. Y.

Sept. 20-25—

Instrument Society of America. Instrument-Automation Conference and Exhibit to be held at the Palmer House and the International Amphitheatre, Chicago. Additional information can be obtained from ISA headquarters, 313 Sixth Ave.,

Chemiseal®

NYLON PRESSURE TUBING COSTS LESS... *Performs Better than Metal*



A decisive cost advantage of CHEMISEAL Nylon Pressure Tubing is shown in this graphic relationship to other tubing materials. Seamless copper and extruded aluminum cost approximately four times as much, while welded and seamless stainless steel costs 29 to 37 times more, respectively. Also, the cost of couplings and installation labor should be considered—CHEMISEAL Nylon Pressure Tubing needs no intermediate couplings or fittings . . . is simple to install. You save on first cost, fittings, and labor.

On the job, other materials don't compare. CHEMISEAL Nylon Pressure Tubing is unaffected by lubricants, alkalies, acids, solvents. It can be twisted, bent, flexed into any position—will resist abrasion, impact, vibrational fatigue. CHEMISEAL Nylon is serviceable from −60° F. to +180° F. (can be heat stabilized for 300° F.); available for 1000 and 2500 psi, conforming to J.I.C. specifications. Diameters range from ⅛" O.D. to largest size commercially made, depending on customer needs.

Discover how you can use CHEMISEAL Nylon Pressure Tubing. Contact one of The Garlock Packing Company's 30 sales offices and warehouses throughout the U.S. and Canada, or write for Bulletin NPT.

THE GARLOCK PACKING COMPANY, Palmyra, N. Y.

United States Gasket

Plastics Division of GARLOCK

Circle 423 on Page 19

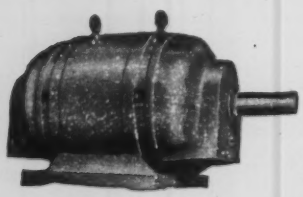
AROUND THE CLOCK PERFORMANCE

that's what you get when you Specify...

VALLEY
BALL BEARING
MOTORS

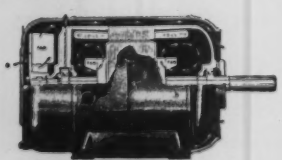
HERE'S WHY...

First of all they are specifically engineered to meet the exacting requirements of most power needs — regardless of type or location. Then too, they insure constant, uninterrupted service in high temperatures because they are always cool running. Having enclosed ball bearings you are assured of complete protection against harmful dust and grit. Furthermore, they can handle most power load emergencies without damage to its operating parts.



FAN COOLED

Totally enclosed VALLEY Motor Polyphase, 50 to 60 cycles, constant speed, continuous duty, squirrel cage induction, high torque, low starting current and fully ball bearing, 2 to 60 h.p.



VALLEY
ELECTRIC CORPORATION
4221 FOREST PARK BLVD. · ST. LOUIS 8, MO.

Circle 424 on Page 19

Pittsburgh 22, Pa.

Sept. 21-22—

Standards Engineers Society. Eighth Annual Meeting to be held at the Somerset Hotel, Boston. Additional information can be obtained from Charles T. Ajamian, P. O. Box 538, Wayland, Mass.

Sept. 23-25—

American Institute of Electrical Engineers — Institute of Radio Engineers. Nonlinear Magnetics and Magnetic Amplifiers Conference to be held at the Shoreham Hotel, Washington, D. C. Further information is available from AIEE headquarters, 33 W. 39th St., New York 18, N. Y.

Sept. 24-26—

Porcelain Enamel Institute. Annual Meeting to be held at the Greenbrier, White Sulphur Springs, W. Va. Further information is available from PEI headquarters, Associations Bldg., 1145 Nineteenth St. N.W., Washington, D. C.

Sept. 28-Oct. 1—

American Welding Society. Fall Meeting to be held at the Sheraton-Cadillac Hotel, Detroit. Further information is available from society headquarters, 33 W. 39th St., New York 18, N. Y.

Sept. 28-Oct. 1—

Association of Iron and Steel Engineers. Convention to be held at the Sherman Hotel, Chicago. Additional information is available from AISE headquarters, 1010 Empire Bldg., Pittsburgh 22, Pa.

"You're calling for too much air pressure."

Sept. 28-Oct. 1—

American Society of Mechanical Engineers — American Institute of Electrical Engineers. National Power Conference to be held at the Muehlebach Hotel, Kansas City, Mo. Additional information can be obtained from Meetings Dept., ASME, 29 W. 39th St., New York 18, N. Y.

Sept. 30-Oct. 1—

Institute of Radio Engineers — American Institute of Electrical Engineers. Industrial Electronics Symposium to be held at the Mellon Institute, Pittsburgh. Further information can be obtained from Robert H. Delgado, 954 Brentview Dr., Pittsburgh 36, Pa.

Oct. 5-9—

Audio Engineering Society. Annual Convention and Professional Equipment Exhibit to be held at the Hotel New Yorker, New York. Further information is available from Harvey Associates, 580 Fifth Ave., New York 36, N. Y.

Oct. 5-10—

Society of Automotive Engineers Inc. National Aeronautic Meeting, including manufacturing forum and engineering display, to be held at The Ambassador, Los Angeles. Further information is available from SAE, 485 Lexington Ave., New York 17, N. Y.

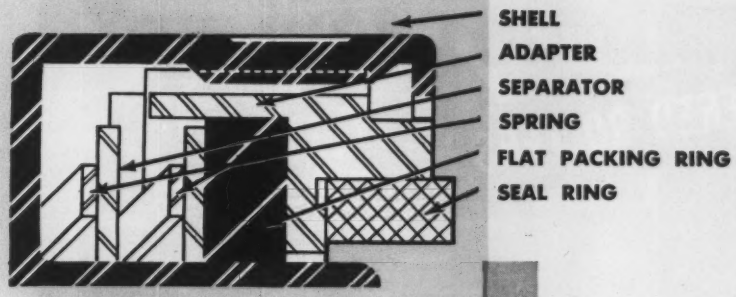
Oct. 7-9—

Gray Iron Founders' Society. Annual Meeting to be held at the Fairmont Hotel, San Francisco, Calif. Additional information can be obtained from society headquarters, National City-E. Sixth Bldg., Cleveland 14, Ohio.

Oct. 12-14—

National Electronics Conference to be held at the Hotel Sherman, Chicago. Further information is available from M. J. Jans, Conference Secretary, Armour Research Foundation, Illinois Institute of Technology, 10 W. 35th St., Chicago 16, Ill.

GITS HH-TYPE SEAL SERIES



VITON "A"

All packings illustrated are available with new Viton "A" rubber compound, for highest temperature resistance and maximum resistance to aircraft and hydraulic fuels and lubricants.

Circle 425 on Page 19

GITS

Extra Flexibility For Your Seal Applications!

ONE SEAL ENVELOPE WITH CHOICE OF FIVE SEAL PACKINGS

Use of this one standard Gits HH-type seal envelope—with your choice of the five seal packing arrangements illustrated at left—permits effective sealing (in the same seal cavity) over the widest possible range of operating conditions. And all these Gits Shaft Seals meet standard minimum space requirements.

Standard metal parts are stainless steel, except when the Gits Engineering Department recommends other materials to suit specific applications.

The sealing and packing members are engineered of proper materials to suit the operating conditions of each individual application.

Gits maintains the most complete facilities for design, engineering, research, development and testing, as well as the most modern manufacturing equipment. The Gits Engineering Department, with almost half a century of experience, has the know-how to blend proper materials with outstanding design, to make seals work better for you. Send for full information

GITS BROS. MFG. CO.

1868A South Kilbourn Avenue • Chicago 23, Illinois

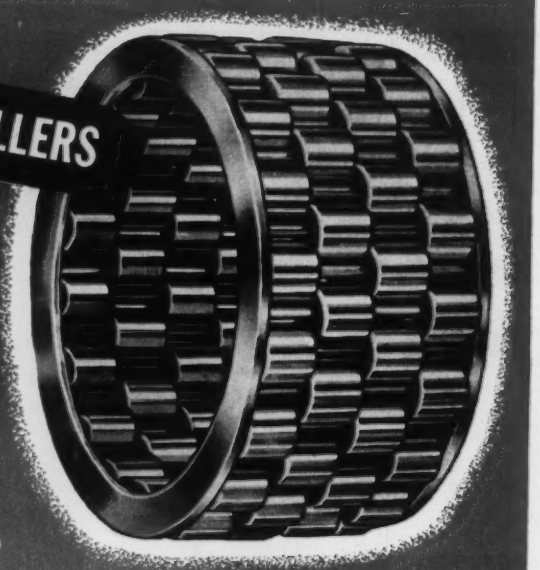
NEW! *Gits engineering advancement practically eliminates hysteresis or drag. Write for full details.*

These SHORT, STAGGERED ROLLERS provide

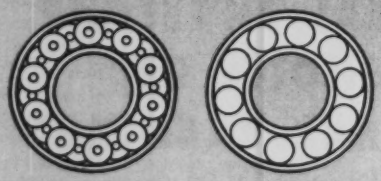
HIGHER LOAD CAPACITY

SMOOTHER RUNNING

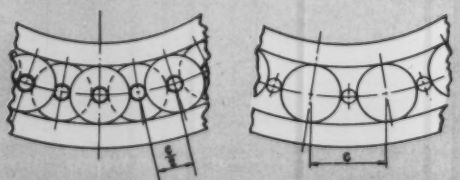
LONGER BEARING LIFE



ORANGE *STAGGERED* ROLLER BEARINGS



More rollers support the load. End views of Staggered Roller bearing (left) and the conventional bearing, show how many short rollers distribute the load over a multiplicity of contact points within the loaded zone.



Closer centers—smoother running. Short, staggered rollers have half the chordal distance of fewer long rollers. More pins add greater rigidity to the cage.

Reduced roller skewing and edge loading. Each row of short rollers aligns itself independently. Under angular misalignment, a short roller can skew only a fraction of a longer roller. In dimensional deviations of component parts or uneven loading, short rollers are much less affected by edge loading thus provide better fatigue life.

Orange Staggered Roller Bearings, with many short rollers in staggered arrangement instead of fewer long rollers, bring you many advantages over conventional bearings.

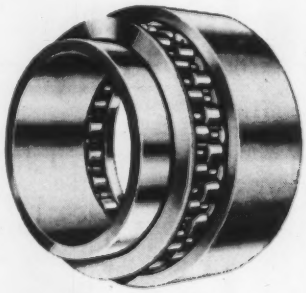
IN HEAVY-DUTY APPLICATIONS the higher load capacity of Orange Staggered Roller Bearings permits the use of smaller bearings, thus saving space and weight. Replacing present bearings, same size, adds extra capacity and longer bearing life.

IN PRECISION APPLICATIONS requiring extremely smooth rotation (such as rolling sheet or foil, rotogravure printing, etc.) the even distribution of load over many contact points provides exceptionally smooth running.

200 and 300 Series. Separable three-part construction—outer race, roller assembly, inner race. Choice of widths and lengths to suit conditions.

C-200 and C-300 Series. This series denotes bearings without inner races for operation on properly hardened and ground shafts.

T-200 and T-300 Series. Designed for use on standard commercial cold drawn shafts. Available for slip fit with inner race notched, or for press fit without notches.



Available in a complete range of sizes interchangeable with other bearings in the 200 and 300 series.

Write for the new 48-page Engineering Reference Manual giving specifications on complete line of Orange Roller Bearings.

ORANGE ROLLER BEARING CO., Inc.
556 Main Street, Orange, N. J.

Needle Bearings — Staggered Roller Bearings
Journal Roller Bearings — Thrust Roller Bearings
Cam Followers

ORANGE
ROLLER BEARINGS

You just roll this sealer on! 3M Ribbon Sealer EC-1202

ROLL-ON RIBBON SEALER EC-1202 creates a uniform, economical, durable seal that shuts out water, dust and moisture.

It's easy to shut wind and weather out of mobile homes with 3M Sealer EC-1202. You just roll this synthetic rubber ribbon on, apply the next piece of metal . . . and fasten mechanically right through the sealer.

Because it's fabric-reinforced, EC-1202 holds its shape, doesn't stretch, sag or shrink. It applies just as easily along curved surfaces.

In mobile homes, this roll-on ribbon makes a weather-tight seal at lap seams and window beddings. And EC-1202 serves boats, curtain walls, commercial refrigeration, too. It's available in various widths and thicknesses direct from your local jobber.

SEE WHAT 3M ADHESIVES CAN DO FOR YOU! Consult 3M Research. Contact your 3M Field Engineer. Or for information and free literature write: A.C.&S. Division, 3M, Dept. SAR-89, 900 Bush Ave., St. Paul 6, Minn.

ADHESIVES, COATINGS AND SEALERS DIVISION

MINNESOTA MINING AND MANUFACTURING COMPANY

. . . WHERE RESEARCH IS THE KEY TO TOMORROW

3M COMPANY

Circle 427 on Page 19

FOR THE ENGINEER

who can't sleep nights

If you're losing sleep over a sticky problem in automatic control, AE can help—because AE has a reputation for making things *work* automatically.

It's not surprising, considering our unique experience in the design of circuits and components for automatic telephone exchanges.

What's more, AE relays and stepping switches are unique in their own right—because they're built to have substantially zero variation in operating characteristics *for life.*

As an example: the AE Class B Relay, illustrated, provides hundreds of millions of operations with unfailing contact reliability, and seldom needs maintenance. For this reason, it is probably the most inexpensive relay you can use where infallibility is an essential.

AE relays and stepping switches are custom-made to *your* specifications—and are also available wired and assembled into complete control units. And we're always glad to suggest specialized circuits that may cut your end costs.

Want more information? Just write the Director, Control Equipment Sales, Automatic Electric, Northlake, Illinois.

Also yours for the asking: Circular 1702-E, *Relays for Industry,* and a new 32-page booklet on *Basic Circuits.*

AUTOMATIC ELECTRIC

Subsidiary of
GENERAL TELEPHONE & ELECTRONICS

The PERFORMANCE is in the DESIGN

Norgren Pressure Regulators

for air and non-corrosive gases

- Improve equipment performance
- Reduce compressed air costs
- Cut maintenance costs

Norgren Pressure Regulators: 1. Reduce line pressure to the desired working pressure; 2. Provide the most efficient operation of connected equipment; 3. Maintain the established pressure even with widely fluctuating line pressure and rapidly varying flow.—***Results:*** Better equipment performance. Longer equipment life. Lower maintenance and compressed air costs.

Highly Accurate Pressure Regulation over a wide operating range. Outstanding performance is the result of these design features: 1. Balanced valve; 2. Large effective diaphragm area; 3. Improved baffle and siphon tube; 4. Large passages; 5. Large valve openings.

Also Norgren regulators for water, oil, other liquids and steam.

For complete information, call your nearby Norgren Representative listed in your telephone directory—or WRITE FACTORY FOR DESCRIPTIVE LITERATURE.

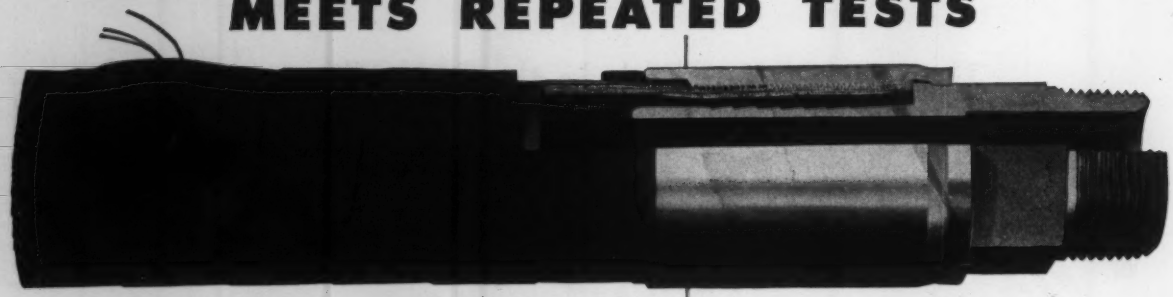
If it's Norgren...It's Dependable.

C. A. NORGREN CO.

3442 SO. ELATI STREET • ENGLEWOOD, COLORADO

Circle 429 on Page 19

Eastman APPLICATION MEETS REPEATED TESTS



Tests prove that Eastman couplings applied to super high pressure 4-ply spiral wire hose assure successful assemblies. Couplings hold well above minimum burst pressure.

PERMANENTLY ATTACHED COUPLINGS PROVIDE BOND STRONGER THAN HOSE ITSELF!

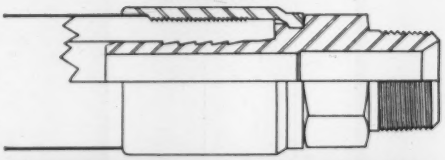
Increasing demand for greater power brought about the use of higher pressures in hydraulic systems. This not only calls for greater hose strength, but far more critical engineering in coupling design and application.

EASTMAN is contributing toward the development of the trend toward higher pressures—not only in the design and application of coupling to hose—but in the more exhaustive tests required to assure adequate safety under high pressure operations.

The actual photo above is typical of many tests in Eastman laboratories proving that the hose did not fail at the coupling—demonstrating that the coupling was designed and applied to form *a bond which was stronger than the hose itself.*

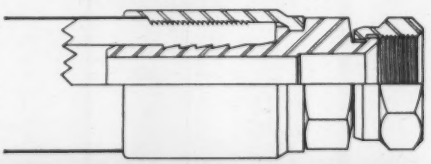
If you have an application requiring higher pressures, let our engineering department demonstrate the superiority and economy of Eastman applications, and quote on complete Hydraulic Hose Assemblies.

MALE NPTF



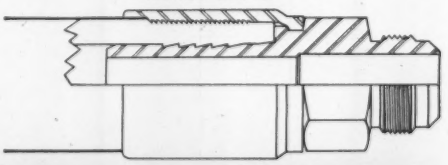
Catalog No.	Hose I.D.	Hose O.D.	Coupling I.D.	Min. Burst Pressure (P.S.I.)	Max. Wkg. Pressure (P.S.I.)
	(inches)				
8412-12M	¾	1 7/16	19/32	20,000	5,000
8416-16M	1	1 ¾	25/32	16,000	4,000
8420-20M	1 ¼	2	1 3/64	12,000	3,000
8424-24M	1 ½	2 ¼	1 21/64	10,000	2,500

SWIVEL FEMALE JIC-37°



Catalog No.	Hose I.D.	Hose O.D.	Coupling I.D.	Min. Burst Pressure (P.S.I.)	Max. Wkg. Pressure (P.S.I.)
	(inches)				
8412-12FH	¾	1 7/16	19/32	20,000	5,000
8416-16FH	1	1 ¾	25/32	16,000	4,000
8420-20FH	1 ¼	2	1 3/64	12,000	3,000
8424-24FH	1 ½	2 ¼	1 21/64	10,000	2,500

MALE JIC-37°



Catalog No.	Hose I.D.	Hose O.D.	Coupling I.D.	Min. Burst Pressure (P.S.I.)	Max. Wkg. Pressure (P.S.I.)
	(inches)				
8412-12MH	¾	1 7/16	19/32	20,000	5,000
8416-16MH	1	1 ¾	25/32	16,000	4,000
8420-20MH	1 ¼	2	1 3/64	12,000	3,000
8424-24MH	1 ½	2 ¼	1 21/64	10,000	2,500

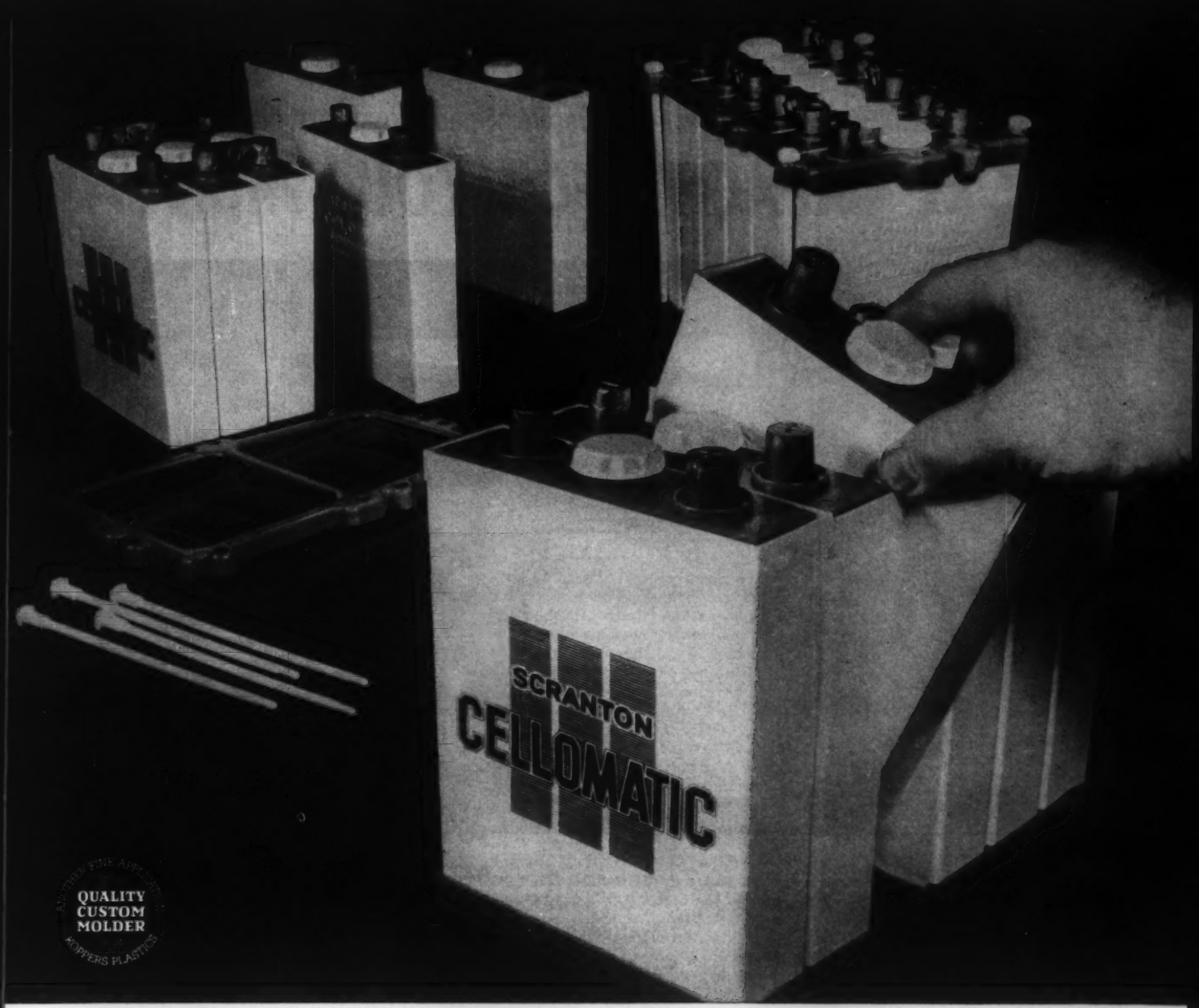
Eastman *first in the field*

MANUFACTURING COMPANY
Dept. MD-8,
MANITOWOC, WISCONSIN

WRITE today for your copies—

Technical Bulletin 100—Medium Pressure Hose and Tube Assemblies, Couplings and Fittings for One Wire Braid Hose.

Technical Bulletin 200—High Pressure Hose and Tube Assemblies, Couplings and Fittings for Multiple Wire Braid Hose.



Manufacturer: Scranton Cellomatic Corporation, Archbald, Pa. Molder: Peerless Plastics, Culver City, California

New-type auto battery uses replaceable cells of light, strong DYLENE® plastic

If one cell dies in this newly designed battery, it isn't necessary to replace the whole battery unit—just the dead cell! What keeps this compact money-saver from being oversized and impractical? DYLENE polystyrene—a tough, heat-resistant and acid-resistant plastic.

DYLENE's superior strength allows the cell walls to be designed so that the multi-celled unit is far lighter in overall weight, and no larger than the old-type automobile battery. DYLENE is dimensionally stable. It molds in varying shapes and sizes; each molded part is identical to the last, and regardless of size or shape, DYLENE retains its basic quality.

The di-electric properties of DYLENE was another reason for its choice. It resists arcing, bridging and seepage of current. Moreover, these cells will last longer, because DYLENE has great resistance to shock, impact and heat. These cells are held firmly in place by frames made of SUPER DYLAN® high-density polyethylene—another fine Koppers plastic.

DYLENE polystyrene is a versatile plastic material. Find out for yourself! Write Koppers Company, Inc., Plastics Division, Dept. MD-89, Pittsburgh 19, Pennsylvania.

see our catalog in SWEET'S

Offices in Principal Cities · In Canada: Dominion Anilines and Chemicals Ltd., Toronto, Ontario

KOPPERS PLASTICS

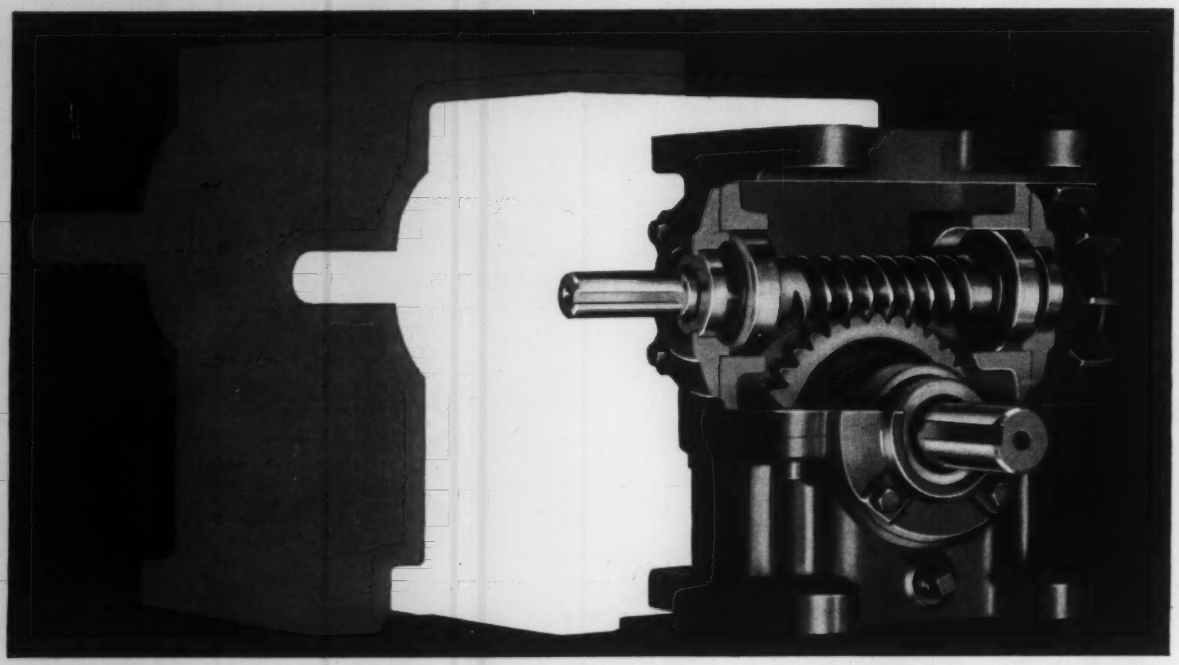
DYLITE® expandable polystyrene, SUPER DYLAN® polyethylene and DYLAN® polyethylene are other fine plastics produced by Koppers Company, Inc.

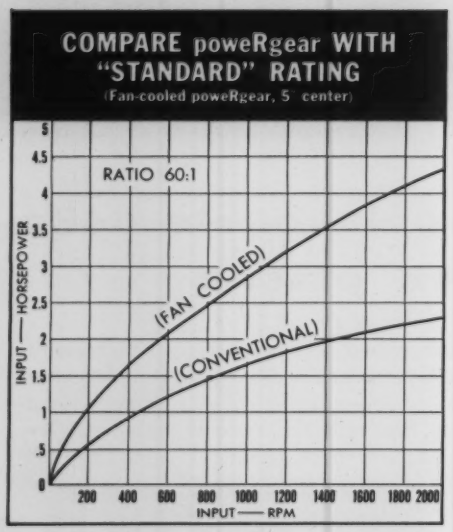
Circle 431 on Page 19

KOPPERS

Based on performance, Morse Eberhardt-Denver Speed Reducers give you:

MORE CAPACITY FOR YOUR MONEY





These curves compare a 5 inch center distance poweRgear with a 5 inch center conventional non-fan cooled heavy duty unit. Because of its fan-cooled design and extra-heavy construction, a Morse E-D poweRgear Speed Reducer easily exceeds "standard" ratings . . . delivers more horsepower per dollar!

Fan and fin cooling, extra-heavy-duty construction let poweRgear® do *more* work in a given size; you save space and weight, often trim initial costs

You get *more* than "rule-of-thumb" ratings call for, when you specify stock Morse Eberhardt-Denver poweRgear Speed Reducers. You pick and pay for the capacity you *need* . . . get it, as set realistically by exhaustive laboratory tests and critical on-the-job ratings.

Fan-and-fin cooling holds operating temperature down, sends rated life up on a poweRgear reducer. Its universal design permits mounting in bottom, top or vertical positions and includes extra-heavy housing, shafts and bearings. Result: you can specify a smaller, lighter, more compact unit to do your job . . . get *more* capacity for every reducer dollar.

There's a Morse E-D poweRgear reducer for *every* job: fractional to 40 H.P.; ratios from 5:1 to 3600:1; center distances from 2″ to 7″. Other Morse E-D speed reducers: conveyor drives; miter boxes; helical reducers; gear motors; worm and gear sets.

FOR MORE FACTS, call your Morse distributor today (see the Yellow Pages under "Power Transmission.") Or write: Morse Chain Company, Dept. 6-89, Ithaca, N. Y. Export Sales: Borg-Warner Intl., Chicago 3, Ill. In Canada: Morse Chain of Canada, Ltd., Simcoe, Ont.

MORSE MORSE BW *Trademark

A BORG-WARNER INDUSTRY

ONLY MORSE OFFERS ALL 4: Chain and "Timing"® Belt Drives; Speed Reducers, Couplings, Clutches

A VITAL 100 MINUTES!

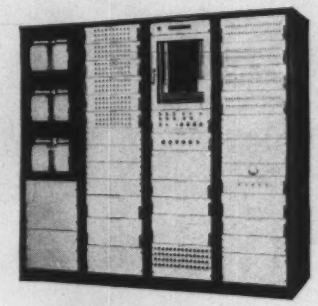
Firing Sequencer with 762 CLARE RELAYS gives automatic control

Automatic control of the countdown at the Air Force's Cape Canaveral Missile Test Center—from X minus 90 minutes to 10 minutes after a missile is fired—is in the hands of a Milgo Model III Sequencer.

The Sequencer, built by Milgo Electronic Corporation, Miami, Fla., automatically controls the myriad operations which must be performed before any missile can be launched. It is preprogrammed to recognize the precise condition that must exist during each of the operations it controls. When any other condition is detected, it will automatically hold fire until the condition is corrected. In a recent instance, it saved a Titan prototype which developed a malfunction after firing but before actual takeoff.

Another of these sequencers is being built by Milgo for installation at the Pacific Missile Range, Vandenberg Air Force Base, Calif.

Milgo engineers selected 762 Clare Type J and Type HG Relays for this supremely important device, and not one has ever malfunctioned. Here is convincing proof that, where the safety of personnel and of valuable equipment is at stake and the utmost accuracy is demanded, a designer who rides with Clare relays can rest assured that he has chosen wisely and well,—not necessarily the cheapest relays but certainly the very best.



Front view of Model III Sequencer which uses 762 CLARE Type J Relays and 14 CLARE Type HG Relays. Made by Milgo Electronics Co., Miami, Fla.

View of control rack of Model III Sequencer showing 56 CLARE Type J sealed relays.

CLARE RELAYS

C. P. Clare & Co., 3101 Pratt Blvd., Chicago 45, Il
In Canada: C. P. Clare Canada Ltd., P. O. Box 13 , Ontario.
Cable Address: CLARELAY

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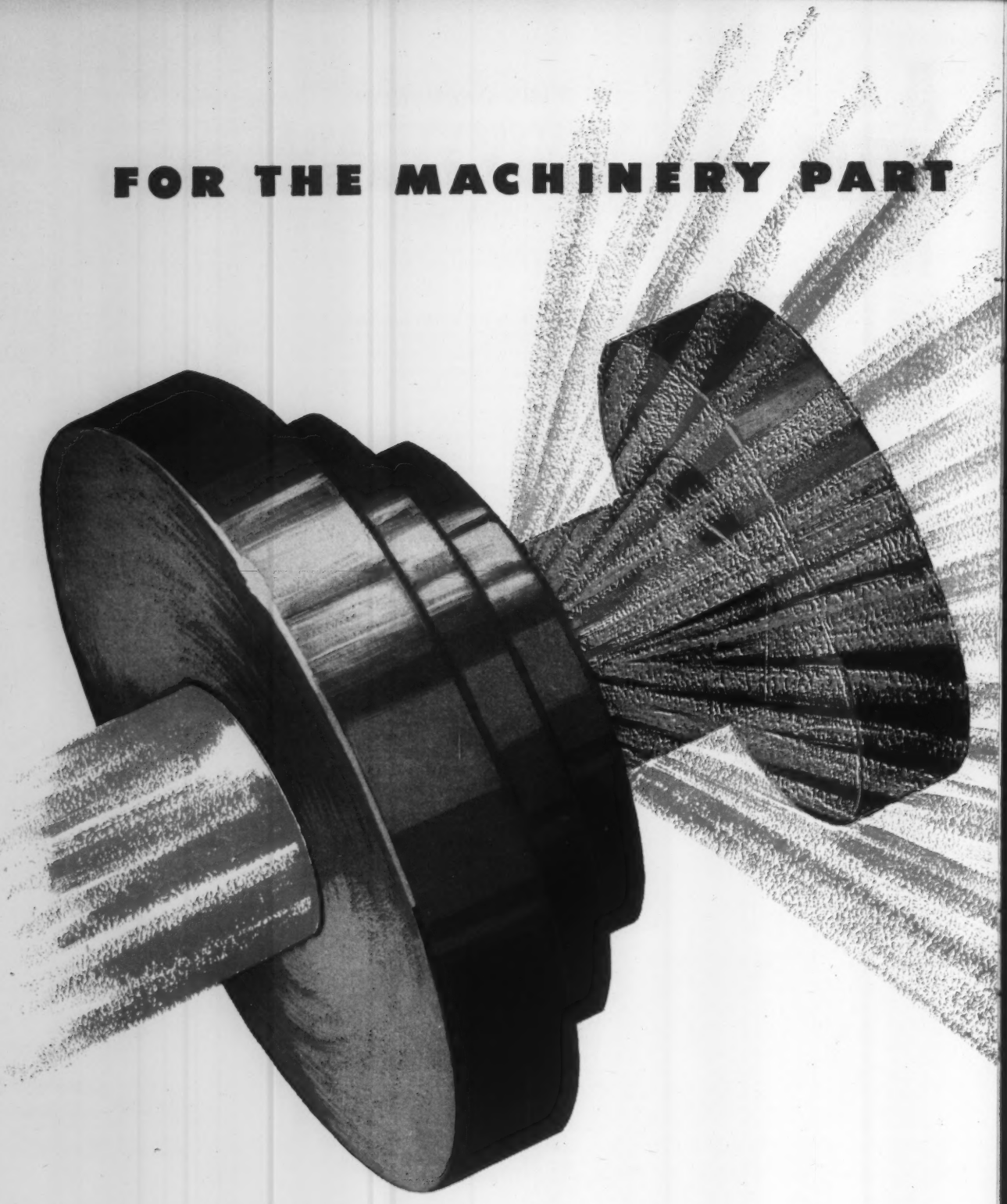
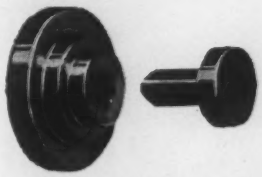
FOR THE MACHINERY PART



THAT TAKES THE BEATING



Liquids forced at high pressure through restricting valves—of HAYNES STELLITE alloy! That's the modern way by which hundreds of products are homogenized today, to make better dairy, chemical, food, and textile products, to name a few.

HAYNES alloys have been a standard material for homogenizer valves for 25 years. Valves that remain free from roughness, porosity, sharp corners, pits. Valves that retain their dimensions where pressures may reach 15,000 psi, and liquid velocities exceed 30,000 ft. per minute. Valves that keep products clean and free from contamination and give long service despite corrosive and abrasive conditions.

If design and production in your field call for tough metal parts, look into HAYNES alloys. There are more than 15 to choose from including HAYNES STELLITE cobalt-base alloys, HAYNES iron-base alloys, HAYSTELLITE cast tungsten carbide, and HASTELLOY nickel-base alloys. They are available as castings, forgings, completely fabricated parts, or as sheet and bar stock. All parts can be furnished machined or ground to specified size and finish.

Our engineers will help you pick the right HAYNES alloy to resist practically any condition of wear, heat, or corrosion. For more information write for descriptive literature.

HAYNES Alloys *will do the job!*

HAYNES ALLOYS

HAYNES STELLITE COMPANY

Division of
Union Carbide Corporation
Kokomo, Indiana

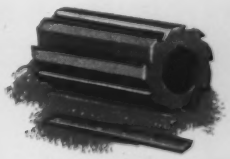
UNION CARBIDE

The terms "Haynes," "Haynes Stellite," "Hastelloy," "Haystellite," and "Union Carbide" are registered trade-marks of Union Carbide Corporation.

TYPICAL "HAYNES" ALLOY MACHINERY PARTS

Chuck inserts of HAYNES STELLITE alloy last up to 50 days—2 shifts daily—holding heavy pieces during a cut-off operation.

Seam rollers on milk-can machines turn out 2 to 3 times as many cans now that the rollers are made of HAYNES STELLITE alloy.



Cutters and bed knives made of HAYNES STELLITE alloy stay clean and sharp for years while pelletizing extruded polystyrene.

Circle 434 on Page 19

#4 CHARACTERISTICS OF HONEYCOMB

While honeycomb has found its greatest application in composite sandwich structures it is expected that a broad area of application will appear as a result of some of the lesser known properties of this material.

Basic Geometry

Hexcel honeycomb is made by laminating strips of foil together with adhesive lines located in such a manner that the resulting bonded stack can be expanded to form hexagonal cells. Figure 1 illustrates various degrees of expansion.

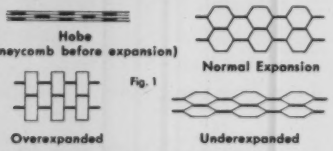


Fig. 1

This basic geometry provides:

1. An extremely high ratio of exposed surface area to the total volume.
2. Virtually all the exposed area is enclosed in regularly oriented unidirectional cells.
3. By varying the cell size and the degree of expansion virtually unlimited adjustment of the foil area to volume relationship may be obtained, as shown in Figure 2.
4. Fluids or gases transmitted through this honeycomb material all travel in the same direction and are uniformly exposed to the surface area.

Physical sizes available include hexagonal cell sizes from ⅛ inch to 1½ inch, cell depths from .060 to 24 inch, and piece sizes up to 42 inch by 96 inch.

5478

INFORMATION REQUEST

Send to Hexcel Products Inc. Dept. 54
2332 Fourth Street, Berkeley 10, California.

NAME_____

TITLE_____

COMPANY_____

STREET_____

CITY_____ ZONE____ STATE_____

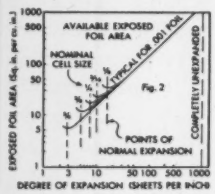

AVAILABLE EXPOSED FOIL AREA
NOMINAL CELL SIZE
TYPICAL FOR .001 FOIL
COMPLETELY UNEXPANDED
POINTS OF NORMAL EXPANSION
EXPOSED FOIL AREA (Sq. in. per cu. in.)
DEGREE OF EXPANSION (SHEETS PER INCH)

Fig. 2

Air Directionalizing

The uniform and parallel cell orientation of expanded honeycomb gives it rather unusual properties in directionalizing air and fluid flow and in minimizing turbulence and rotational flow. Extremely small edge areas of the .001 inch to .004 inch foil used results in a low pressure loss. These properties have been used in applications from home coolers and grilles to wind tunnel straightening vanes. A piece of honeycomb oriented at an angle to the direction of flow can be used as a directionalizing material. Figure 3 illustrates the efficiency of honeycomb as used in grilles and registers.

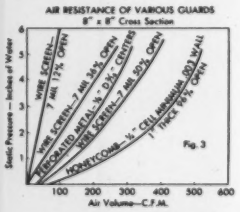

AIR RESISTANCE OF VARIOUS GUARDS
8" x 8" Cross Section
Static Pressure — Inches of Water
WIRE SCREEN—7 MM. 34% OPEN
WIRE SCREEN—7 MM. 17% OPEN
PERFORATED METAL—⅜" DIA. CENTERS
WIRE SCREEN—7 MM. 57% OPEN
HONEYCOMB—½" CELL MINIMUM .001 FOIL
1" THICK 99% OPEN
Air Volume—C.F.M.

Fig. 3

RF Noise Filters

Honeycomb has been used in the grilles and registers of shielded radio equipment. In this application, honeycomb acts both as an RF shielding device; as an efficient air directionalizing device; and is effective as an RF shield for all frequencies below the cut-off frequency of the cell size and thickness used.

Light Directionalizing

One grade of aluminum honeycomb, "HONEYLITE", has found wide application as a lighting louver, particularly in overall luminous ceiling applications. This characteristic of honeycomb indicates broader use in the collimation of not only visible light, but also ultraviolet and infrared.

Heat Exchangers

The extreme high ratio of surface area to unit volume provided by honeycomb materials can offer many possibilities in heat exchanger applications. Materials available for use in this application include two aluminum alloys plus a variety of stainless steel alloys, in both resin bonded and welded node construction.

Anti-Slosh Devices

Honeycomb has been used as a baffle or anti-slosh device both in fully enclosed sandwich fuel cell structures and in non-sandwich applications. The material can be readily drilled for lateral flow from cell to cell.

Design Opportunities

It can be seen that honeycomb offers to the designer many properties and possible combinations of properties which open up wide areas of potential application. The applications themselves seem limited only by the imagination of those who make use of the material.

Others in This Series. Copies sent on request

1. **Honeycomb Sandwich Panels**
2. **Honeycomb Sandwich Materials**
3. **Successful Honeycomb Sandwich Design**

HEXCEL® PRODUCTS INC.
World leader in honeycomb

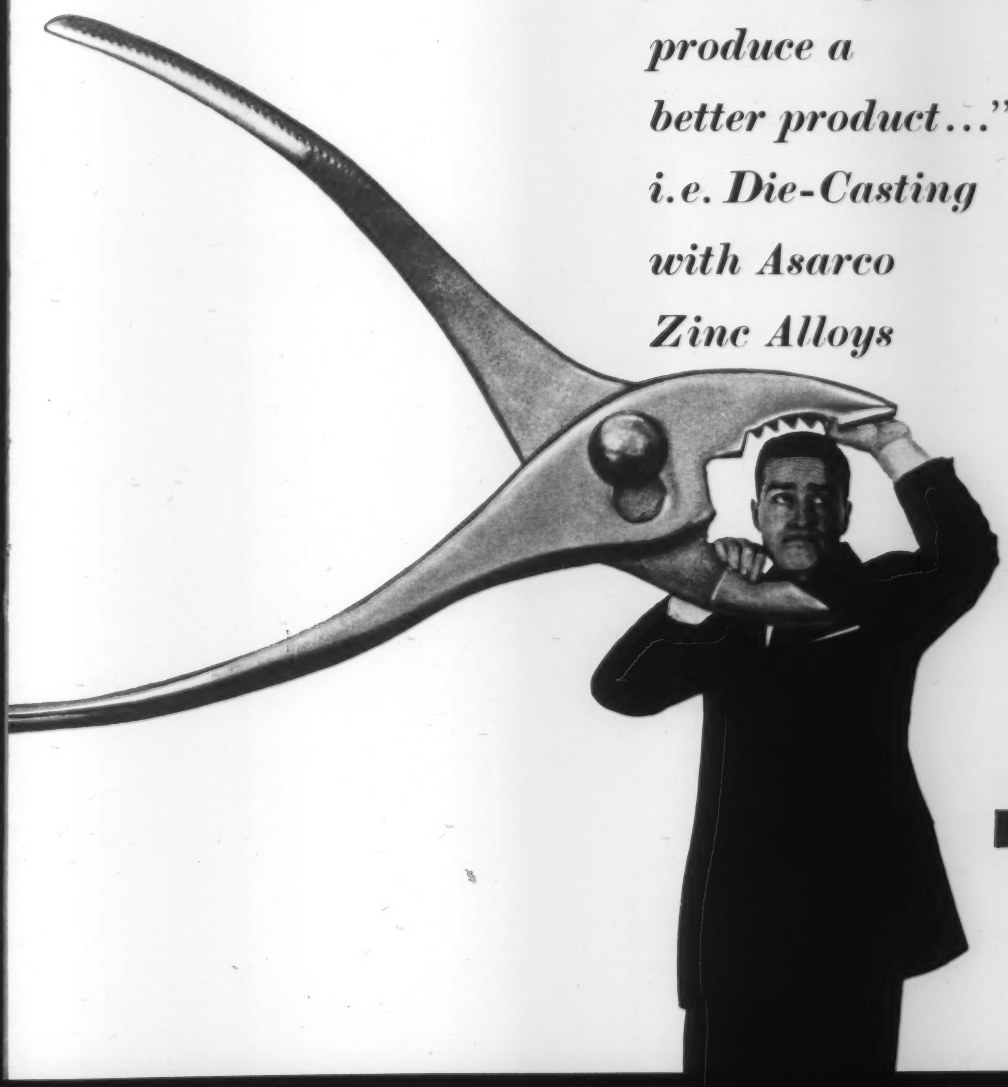
Executive Offices: 2332 Fourth Street, Berkeley 10, Calif.
Plants: Oakland and Berkeley, Calif.; Havre de Grace, Md.
Sales Offices: Long Island City, N.Y.; Fort Worth, Texas; Inglewood, Calif.

Circle 435 on Page 19

Circle 436 on Page 19→

ASARCO

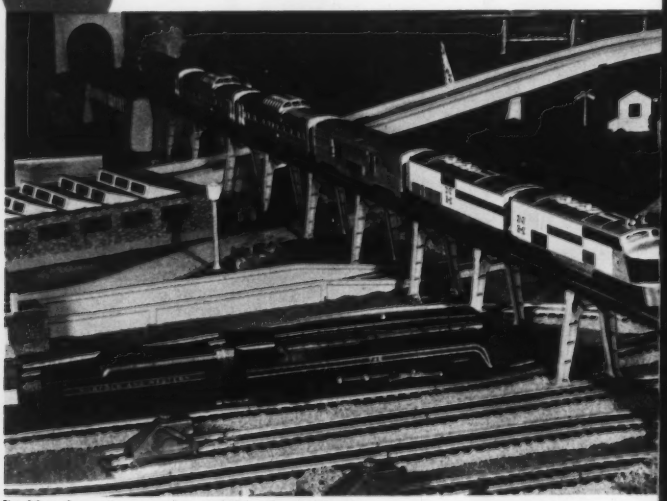
"the fast way out of today's profit squeeze is through the use of more efficient materials which cost less to machine and fabricate, yet produce a better product..."
i.e. Die-Casting with Asarco Zinc Alloys



SEE NEXT PAGE

Die-Casting with Asarco's Federated

Low machining costs, superior castability, and an excellent plating surface are the big reasons why Di-Metal castings are favored for fuel pumps, carburetors, grilles, lamp housings, instrument panels, horn rings, and many other functional and decorative automotive components.



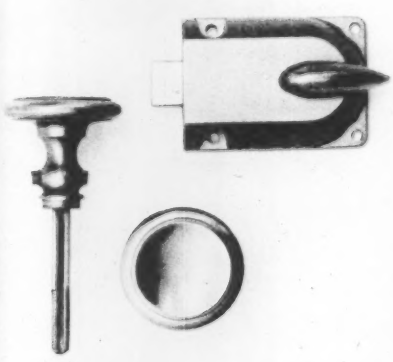
Di-Metal castings make possible the faithful reproduction of detail that's so important in producing trains and other toy miniatures which look "just like the real thing."

The low cost, fine detail, complex shapes, and brilliant finish possible with zinc die-casting has become increasingly appealing to manufacturers of costume jewelry.

Di-Metal Zinc Alloys can cut your costs...and produce a better product in the bargain!

Every designer will sit up and take notice when he sees how easy it is to produce miniature objects with movable parts, even linkage, in one Di-Metal zinc casting. This is actual size of die-cast scissors.

Zinc die-casting provides the hardware field with the smooth cast surfaces so necessary in producing an attractive, lasting finish.



When gears, cams, hubs, and shafts can be integrally cast in one piece by zinc die-casting, a costly assembly operation is eliminated.

There's a big swing in metal parts production today to die casting with zinc—and it certainly makes good sense.

For one thing—Federated Di-Metal (alloyed from Asarco's Special High Grade Zinc 99.99 plus % pure) is lower in material cost.

But the big savings come in production. The low melting point of Federated Di-Metal cuts casting time to the bone. Die casting at lower temperatures calls for less expensive dies—and they last far longer.

Castings can be held to very close dimensional tolerances so that there's a minimum of machining and finishing. And even when this is necessary, highly ductile zinc is easy to work.

Die casting with Federated Di-Metal can produce the most complex shapes, the thinnest section walls, the smoothest casting surfaces. The castings have impact strength and other mechanical properties superior to other casting metals (with the possible exception of copper which, of course, costs more). And zinc die-castings can be readily electroplated or coated.

When you're both cost and quality conscious, you can't afford to by-pass die casting with Federated Di-Metal. It is proving the fastest way out of the present "profit squeeze" for a growing list of manufacturers in many fields.

When You Die-Cast Your Product with Asarco's Federated Zinc Di-Metal, You Profit from:

1. Integrated Production. Federated Di-Metal is alloyed using electrolytically refined Special High Grade Zinc from ores mined by Asarco. Alloys are produced "under one roof" at Corpus Christi, Texas, one of the world's largest electro zinc producing plants — assurance of highest purity and uniformity at lowest cost.
2. Nation-wide Service and Distribution. Always a Federated field engineer near you, on call from 23 sales offices throughout the country. Federated Di-Metal is stocked for immediate shipment from a nation-wide system of distribution centers.
3. Asarco booklets and bulletins of great working assistance to the die casting industry, detailing efficient working practices, selection of alloys, vital technical data. Write for your free copy of "For Better Die Castings," to your nearest Federated Sales Office or to ASARCO Federated Metals Division, 120 Broadway, New York 5, New York.

ASARCO

AMERICAN SMELTING AND REFINING COMPANY

Other ways it pays to THINK ZINC when you're cost-and-quality conscious:

GALVANIZED STEEL. The strength of steel, the corrosion resistance of zinc—at low cost. New processing methods assure uniformly thick zinc coating. Galvanized steel can be drawn or formed. Roofing and siding sheets for farm and industrial buildings are low in initial cost, installation cost, and maintenance cost. Corrugated culvert pipe is easy to transport and install, flexible, strong, durable. Galvanized sheets are superior materials in heating and air-conditioning installations—cost less, fabricate more easily, are more rigid for longer unsupported spans, operate quieter since they expand and contract less than comparable materials.

Zinc products available from Asarco:

ZINC SLAB, Prime Western, Brass Special, Intermediate, High Grade, Special High Grade;
ZINC ANODES for cathodic protection of ship hulls and other submerged steel structures;
ZINC DUST, 97% metallic zinc, 97% through 325 mesh screen;
ZINC FOIL for barrier wraps, insulation;
ZINC ALLOYS for die-casting.

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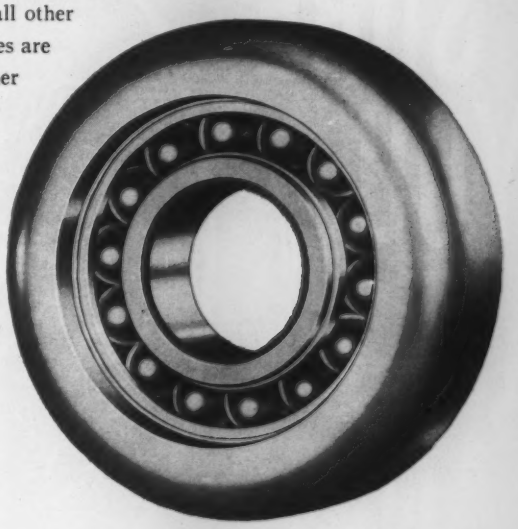
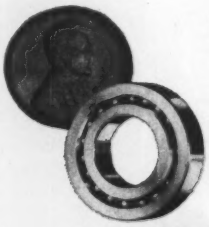
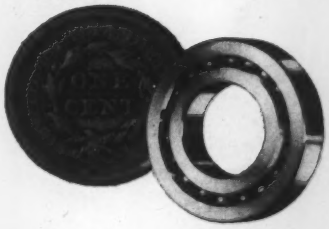


The design possibilities in this new Heim method of construction are almost unlimited. One example is this 4″ heavy duty bearing for high radial and axial load conditions.

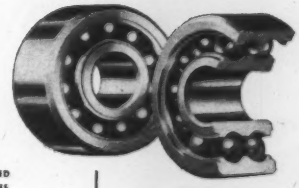


Bearings with plain outer members in small sizes.

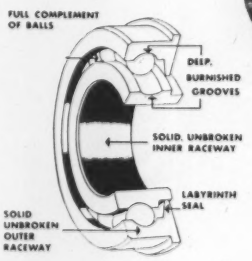


. . Medium sizes or sizes to 2″ diameter and over

Bearings with flanged outer members in all sizes



Double row type bearings.



Send for bulletin UBB showing stock sizes and capacities, or ask about special applications.

Manufactured by THE HEIM COMPANY
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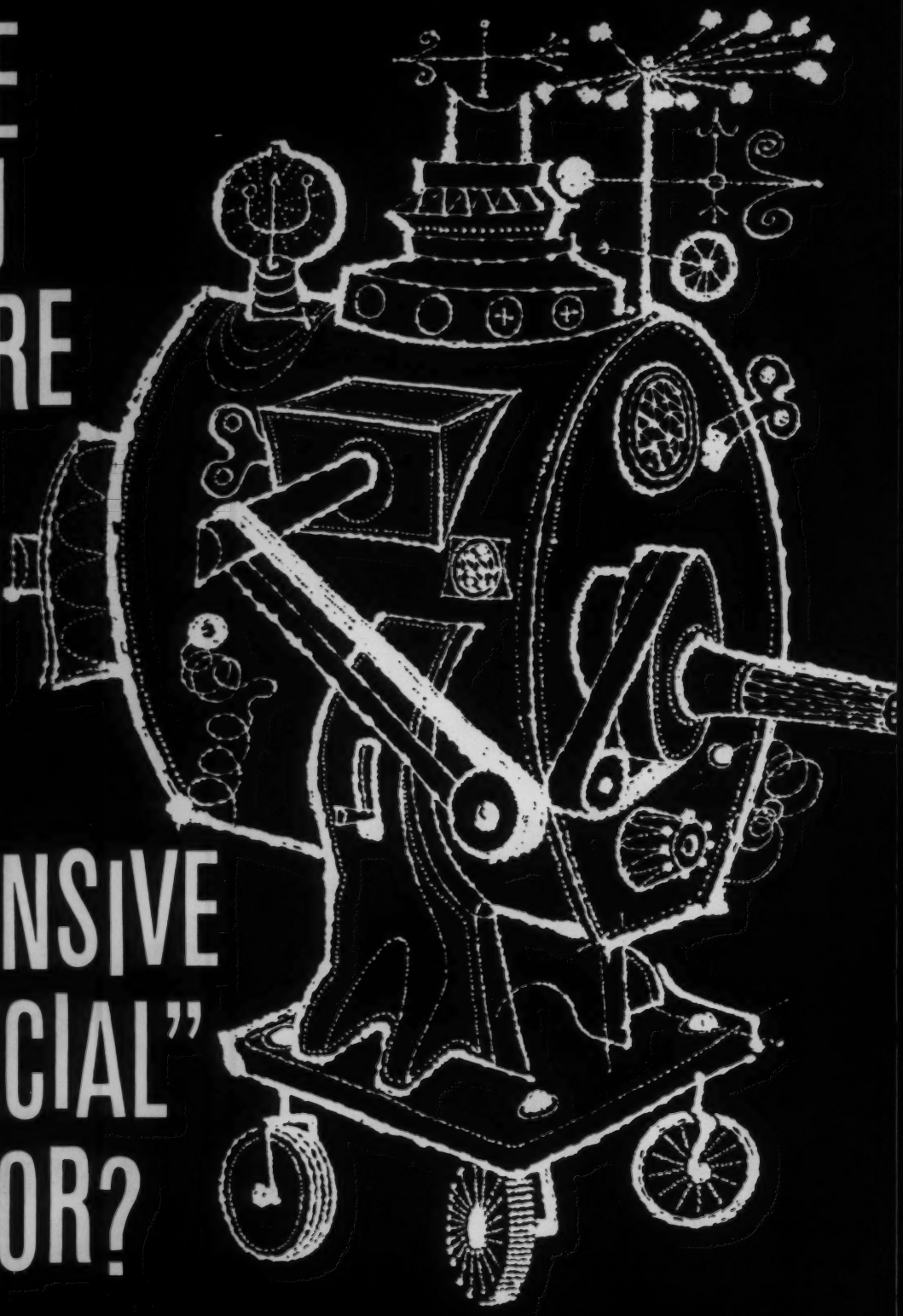

INEXPENSIVE WESTINGHOUSE STANDARD MOTORS HAVE BEEN DOING "SPECIAL" JOBS FOR YEARS!

Sometimes you have to use a "special" motor. But *not usually!*

Even though your application is a "special" one, the chances are excellent that you can apply a *Westinghouse standard* fhp motor without a loss in efficiency, appearance or output—and at a much lower cost.

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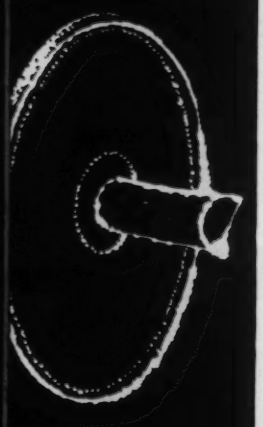

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REPAIR FACILITIES! . . . on almost every corner.

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Call in your local Westinghouse sales engineer today and ask him to look over your fhp motor application. It's a good bet that all you're getting with your present "special" motor is a "special" (higher) price.

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J-03026

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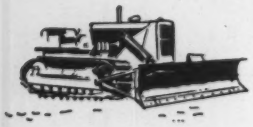
Circle 438 on Page 19



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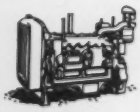

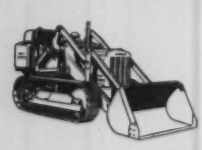

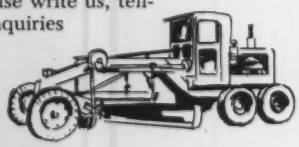

(Below – New Caterpillar Technical Center presently under construction)

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SEND RESUMÉS TO:
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PEORIA, ILLINOIS

Circle 439 on Page 19

Circle 440 on Page 19→

THE NEW

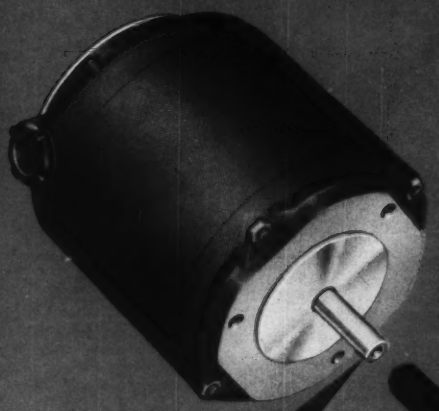
SYNCHRONOUS MOTORS

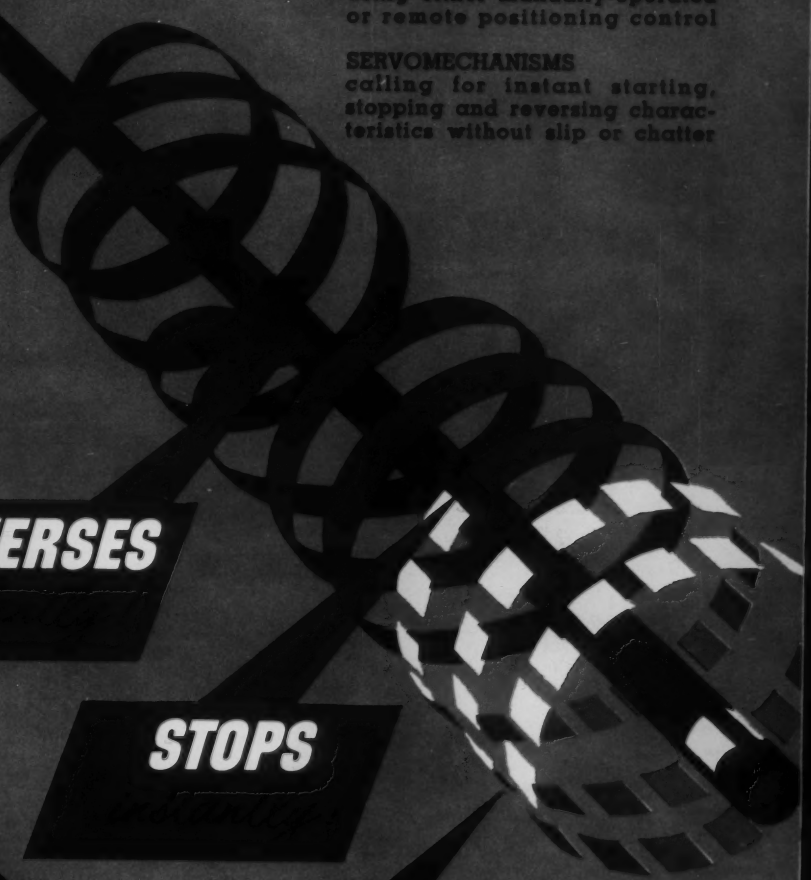
AUTOMATIC MACHINES AND APPARATUS
needing a simple, efficient, maintenance-free synchronous motor

NUMERICAL CONTROL SYSTEMS
requiring continuous, constant-speed traverse and/or incremental stepping for positioning

REMOTE CONTROL SYSTEMS
using either manually-operated or remote positioning control

SERVOMECHANISMS
calling for instant starting, stopping and reversing characteristics without slip or chatter





STARTS

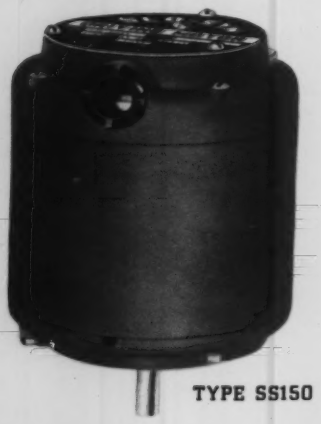
REVERSES

STOPS

THE
SUPERIOR ELECTRIC
COMPANY

Bristol, Connecticut, U.S.A.

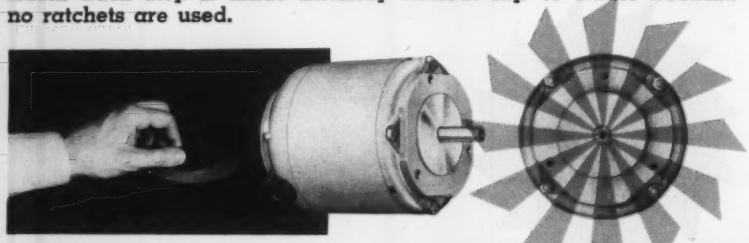
A SLO-SYN is an enclosed, permanent magnet type a-c motor with a slow basic shaft speed of 72 RPM. A single-pole, three-position switch can give complete forward, reverse and "off" control because the motor has three leads only. The SLO-SYN Motor will start or stop in less than 0.025 seconds or approximately 1.5 cycles. No need for electrical or mechanical braking because the motor will stop in less than 5° of shaft rotation. Maximum moment of inertia of a load rigidly attached to the shaft is 1.5 pound-inches². Loads with higher inertia can be started by using a coupling method which allows 5° freedom. Types having specially-designed planetary gear assemblies are available to provide speeds of 3.323, 0.665, 0.133 or 0.027 RPM. Torque on all planetary gear types is 2500 ounce-inches.

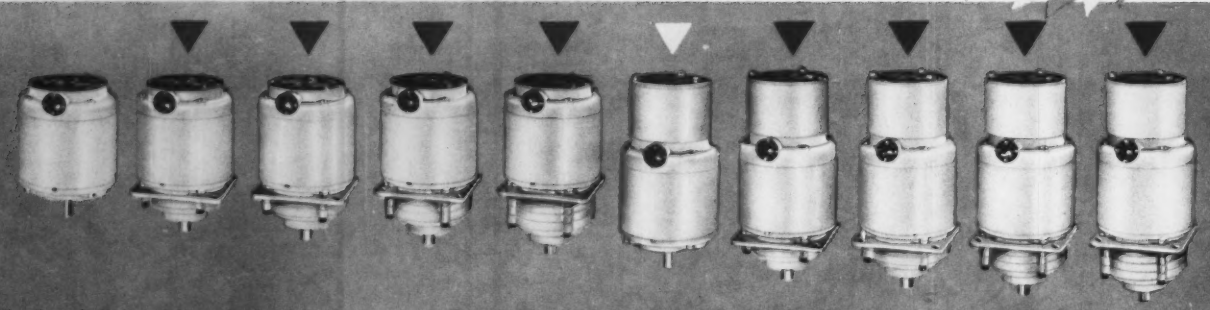


TYPE SS150

AS A D-C STEPPING MOTOR

The SLO-SYN Synchronous Motor can be adapted for use as an incremental stepping device by the use of a d-c power source and a suitable switching arrangement. When used as a control system stepping or "inching" motor, d-c electrical impulses are converted into either 200 or 400 precise increments of one revolution of the motor shaft. The motor will maintain its rated torque for any stepping position. Each step is made instantly without slip or clatter because no ratchets are used.



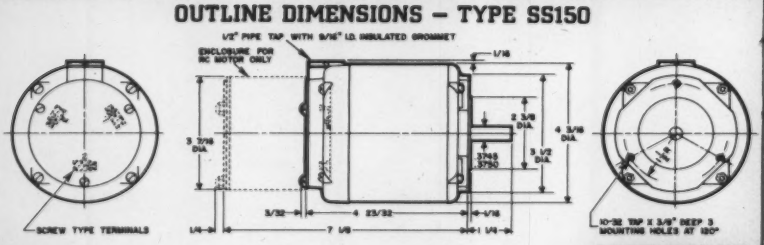


▼ Available with speed reducing planetary gears ▼ Available with enclosed capacitor and resistor ▼ Available with both enclosed capacitor and resistor and planetary gears

RATINGS AND SPECIFICATIONS

INPUT	120 volts, 40/70 cycles, 1 phase
OUTPUT SPEED	72 RPM at 60 cycles
MAX. CURRENT	0.3 ampere at 60 cycles
TORQUE	150 ounce-inches
WEIGHT	6.5 pounds

OUTLINE DIMENSIONS – TYPE SS150



THE SUPERIOR ELECTRIC COMPANY, Bristol, Connecticut

☐ Please send SLO-SYN Synchronous Motor Bulletin

☐ Please have your representative call.

name

company

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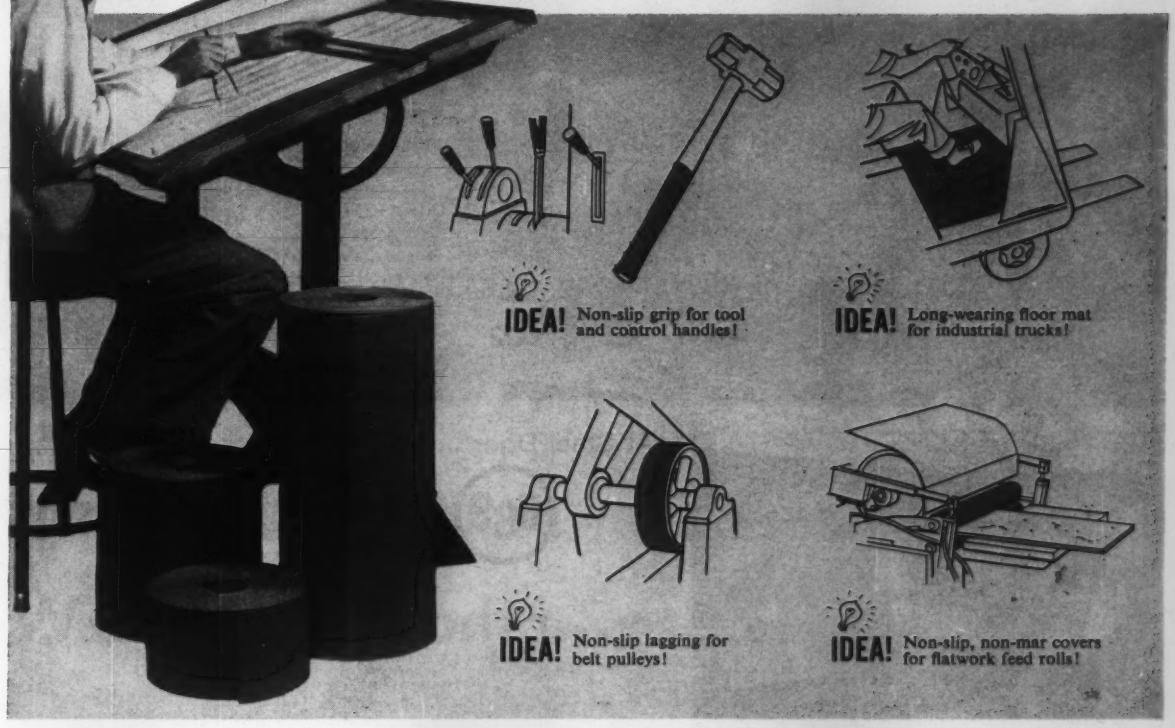
. . . FOR YOUR FILES

Request SLO-SYN Bulletin giving full technical information, ratings and specifications.

THE SUPERIOR ELECTRIC COMPANY

Bristol, Connecticut, U.S.A.

Versatility plus application ease make "SCOTCH-TRED" a stimulating IDEA material for more creative product design


IDEA! Non-slip grip for tool and control handles!
IDEA! Long-wearing floor mat for industrial trucks!
IDEA! Non-slip lagging for belt pulleys!
IDEA! Non-slip, non-mar covers for flatwork feed rolls!

Amazing new "SCOTCH-TRED"—resilient non-slip surfacing—IDEA material of a thousand uses!

FUNCTIONAL! Durable "SCOTCH-TRED" has a textured surface with high capabilities in slip and skid elimination. Resilient under foot or under pressure . . . extra long-wearing . . . non-sparking. Easily cleaned with soap and water.

DECORATIVE! Modern soft decorator colors—beige, gray, black—harmonize with any scheme. Pleasantly textured surface is soft, pliable, brings new comfort to safety conditioning.

VERSATILE! Pliable "SCOTCH-TRED" will conform smoothly to almost any surface; can be cut with scissors, knife, or die; pressure-sensitive adhesive sticks at a touch to any surface. Available in ¾" x 24" strips; 9" squares; bulk 96-foot rolls from 4" to 36" in width. Complete information and prompt service available through local wholesalers. Contact your nearest 3M office.

See our insert in Sweet's Product Design File, 4b Mi.

"SCOTCH-TRED" and "SAFETY-WALK" non-slip surfacings are manufactured in U.S.A. by 3M Co., St. Paul 6, Minn. Export: 99 Park Ave., New York 16. Canada: London, Ontario.

MINNESOTA MINING AND MANUFACTURING COMPANY

3M COMPANY

. . . WHERE RESEARCH IS THE KEY TO TOMORROW

FOR EXTRA HEAVY-DUTY NEEDS, 3M's "SAFETY-WALK" is often used. A mineral coated fabric that is practically indestructible, "SAFETY-WALK" stands up well under abuse and punishing traffic.

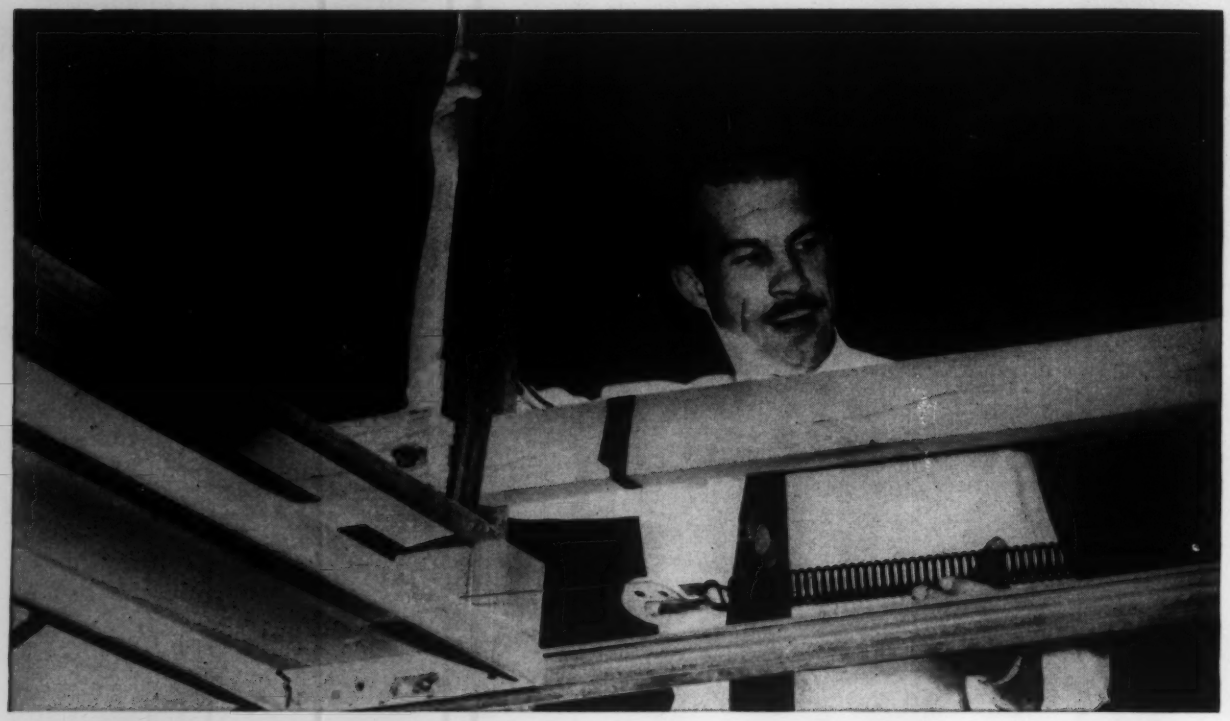
scotch•tred BRAND
Resilient NON-SLIP SURFACING

SEND FOR FREE SAMPLE . . . USE THE COUPON

3M CO., Dept. AAX-89
St. Paul 6, Minn.

☐ Rush free sample of "SCOTCH-TRED".
☐ Send sample and information about "SAFETY-WALK".

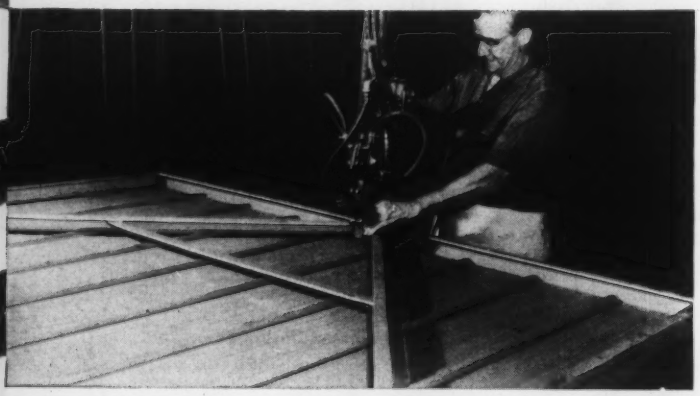
Name_____
Firm_____
Address_____
City_____ Zone____ State_____



At Steel Door . . .

USS American Springs thanks to AS&W

In the American Steel & Wire Fatigue Laboratory, a technician runs tests on a USS American Spring, designed for Steel Door use. On the basis of this test a change in hook design was recommended to give longer spring life.



A Steel Door workman assembles a Berry One-Piece Door. This company uses steel exclusively for all doors because of its many consumer advantages. Steel is stable, won't warp or swell. Steel doors need less maintenance and preparation, and steel doors are easy to operate.

This close-up shows the improved hook on the extension springs supplied by American Steel & Wire for the Steel Door overhead garage doors.

stretched 31,000 times and still going strong...

Spring Engineering Research Service

The Steel Door Corporation, Birmingham, Michigan, is the world's largest manufacturer of residential garage doors. For the production of these doors they use about 150,000 USS American Springs every year. Steel Door asked American Steel & Wire for a statistical evaluation of the fatigue life of the extension hook-type springs they use. The AS&W Spring Engineering Research Service tested these springs in the Fatigue Laboratory and recommended a change in hook design.

So successful was this design change that the life of the springs has been materially increased. At the Steel Door plant a cycle test was set up using USS American Springs on an overhead door. At the present time these springs have completed over 31,000 cycles without showing any sign of failure. This is the equivalent of 25 years of normal usage.

Mr. Ralph Qualman, Advertising Director and Service Manager, says: "It is extremely important that the springs—especially those used on sectional doors where the strain is greatest—have proper tension and a long life. American Steel & Wire supplies Steel Door with springs that meet their engineering specification and life expectancy."

If you have a spring problem or would like advice on the use of springs in your product, get in touch with our general offices in Cleveland, or any American Steel & Wire Sales Office. You can benefit from the knowledge of AS&W's Spring Engineering Research Service. The Service has been engaged in laboratory experiments of static and dynamic testing for 20 years and has accumulated invaluable data on stress and fatigue life of steel springs, while endeavoring to improve efficiency in the use of steel—from steel chemistry through product application—to more economically cope with today's rigorous demands. This accumulated knowledge of the AS&W Spring Engineering Research Service is at your disposal. *American Steel & Wire, 614 Superior Ave., N.W., Cleveland 13, Ohio.* *USS and American are trademarks*

American Steel & Wire Division of USS **United States Steel**

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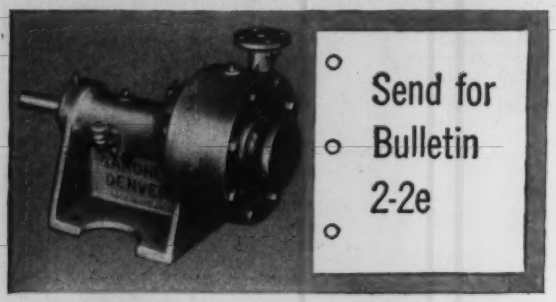
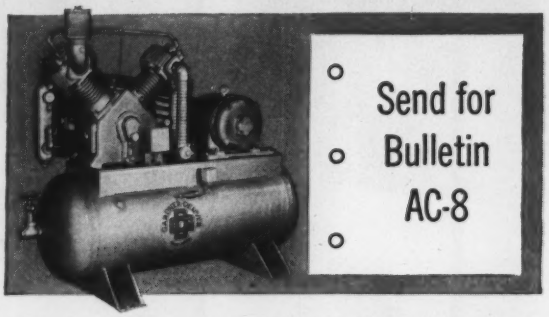
If your design moves water, uses air power . . . design in these dependable components



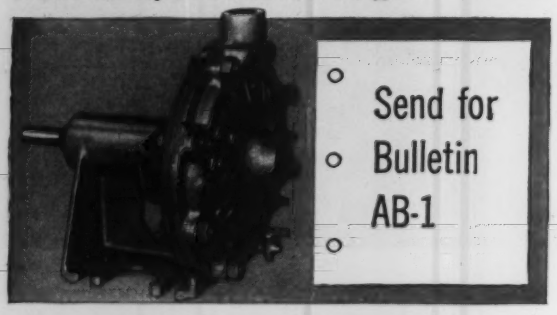
Send for Bulletin 2-2e

High-speed, high-head pumps for big water volume — Gardner-Denver BH centrifugal pumps. 1″, 1½″, 2″ and 3″ sizes with capacities from 55 to 550 gpm.



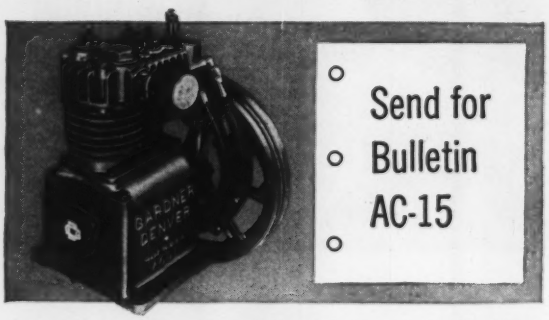
Send for Bulletin AC-8

Plus-value compressor outfit — Gardner-Denver ADL displaces 100 cfm. Pressures to 125 psi. Two-stage, air-cooled.



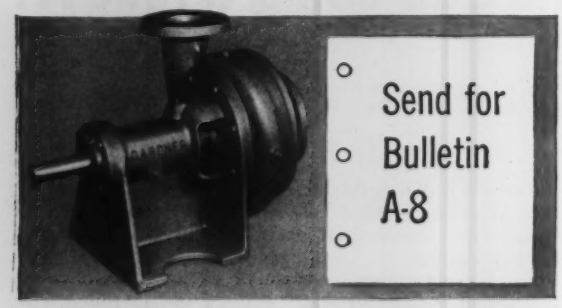
Send for Bulletin AB-1

Reverse rotation without alteration—Gardner-Denver CAY 1″ centrifugal pumps. Handle up to 65 gpm.



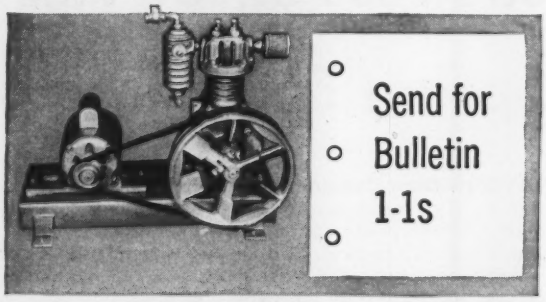
Send for Bulletin AC-15

Designed to outlast any other small compressor—Gardner-Denver ADD two-stage compressors. Rated at 25 cfm displacement.



Send for Bulletin A-8

Top pumping efficiency over broad service range — Gardner-Denver BL centrifugal pumps. 2″, 3″, 4″, 5″ and 6″ sizes provide capacity range from 100 to 1600 gpm.



Send for Bulletin 1-1s

Compact compressor package provides low-cost, oil-free air—Gardner-Denver CACB supplies 4 to 5 cu. ft. of air per min. Suitable for discharge pressures of 40 to 100 psi.

TESTING NEVER ENDS

Superior performance in a product is never an accident. Gardner-Denver men put equipment through its paces, and continually look to improve efficiency and quality. At Gardner-Denver there's no substitute for men—our 100-year philosophy of growth.

Remember, all Gardner-Denver products are backed by a world-wide parts and service network. Wherever the equipment you design is put to work, you're sure of factory-trained service on the spot. See your Gardner-Denver pump and compressor specialist, or send for the special bulletin above.

EQUIPMENT TODAY FOR THE CHALLENGE OF TOMORROW

GARDNER-DENVER

Gardner-Denver Company, Quincy, Illinois

In Canada: Gardner-Denver Company (Canada), Ltd., 14 Curity Avenue, Toronto 16, Ontario

Circle 443 on Page 19

The Valve Catalog to Reach For FIRST

HELPFUL FEATURES

FOUR TYPES OF INDEXES LEAD QUICKLY TO DATA NEEDED
Four-way indexing—General, Alphabetical, Fig. No., and Sectional—leads the reader instantly to the information desired, from any point of reference . . . pattern, metal, number, or function.

VALVE SPECIFICATIONS LIST ADVANTAGES AND MAJOR USES
Every Jenkins Valve in every group,—Bronze, Iron, Cast Steel, and Stainless Steel—is fully illustrated and described in detail, with an explanation of its principal advantages and uses.

HELPFUL INSTRUCTIONS FOR CHOOSING AND USING VALVES
Thirteen pages of basic information,—"Fundamentals of Valve Design and Application"—serve as a guide in selecting the correct type of valve, and provide instructions for their proper installation and maintenance to assure maximum service life.

USEFUL TABLES AND REFERENCE DATA TO WIN FAVOR OF ENGINEERS
In the 23 pages of the "Engineering Data" section, Catalog No. 56 provides a compilation of useful required tables, charts, and codes —the information wanted by the men who plan piping layouts . . . *and specify valves.*

For clear, complete, easy-to-find data on valves and how to select and use them, no other single book compares with this latest Jenkins Catalog

From cover to cover this 296 page general catalog of Jenkins Valves was designed to give specifiers and buyers all the data they want . . . and FAST. It's the book to reach for FIRST when you need valves or valve information. To get your copy, write (on your letterhead) to Jenkins Bros., 100 Park Avenue, New York 17.

JENKINS VALVES

Sold Through Leading Distributors Everywhere

Circle 444 on Page 19

Silicone Sponge Rubber

remains flexible at extreme temperatures
−100° F to 500° F

COHRlastic R-10470 silicone sponge rubber has a dense, uniform, non-absorbing closed cell structure, highly suitable for soft gasketing, vibration dampening, fairing strips, seals, pads, bumpers, dynamic cushions and other applications where resiliency at extreme temperatures is required. It has superior compression set resistance, excellent dielectric properties, immunity to aging, ozone and weather hardening and good chemical resistance — non-sticking, odorless, non-corrosive.

COHRlastic R-10470 can be bonded to metals, plastics, fabrics or silicone rubber. Sheets 24″ x 24″ and in thicknesses 1/16″ through 1/2″ are available from stock. Larger sizes up to 30″ x 30″ and special molded and extruded shapes are made to order. CHR silicone sponge rubber is sold nationally through distributors.

FREE SAMPLES and folder — write, phone or use inquiry service.

COHRlastic R-10470
Silicone Sponge Rubber

SPECIFICATIONS:

COHRlastic R-10470 meets many specifications. Some are listed below:

AMS 3195
AMS 3196
MIL-R-6130A type 2
Boeing BMS 1-23
Martin MC1 4546
Martin MB 6130
Bendix ES 0709
Douglas DMS 1597
Lockheed LAC 1-924

PROPERTIES	Range of typical properties COHRlastic R-10470	Typical accepted standards
Tensile	50-130 psi	40 psi, min.
Elongation	175-225%	125% min.
Water absorption (Immersion 24 hrs. @ 75°F.)	3-6%	10% max.
Density, lbs./cu. in.	.020-.030 (firm)	.030 max.
	.013-.018 (medium)	.020 max.
Low temperature brittleness (5 hrs. @ −100°F., bend flat)	No cracking	No cracking
Compression deflection (compressed to 75% of original thickness)		
Room temperature		
Type firm	12-18 psi range[1]	12 min.-20 max. psi
Type medium	8-14 psi range[1]	6 min.-14 max. psi
−65°F. pct. difference	−10% to +15%[1]	
212°F. pct. difference	+5% to +10%[1]	
Compression set (compressed to 50% of original thickness)		
22 hrs. @ 70°F	0-5% (firm)[1]	10% max.
	5-30% (medium)[1]	40% max.
22 hrs. @ −65°F	0-5% (firm)[1]	10% max.
	5-30% (medium)[1]	40% max.
22 hrs. @ 212°F	10-25% (firm)[1]	30% max.
	20-50% (medium)[1]	60% max.

1 ASTM D 1056-56T

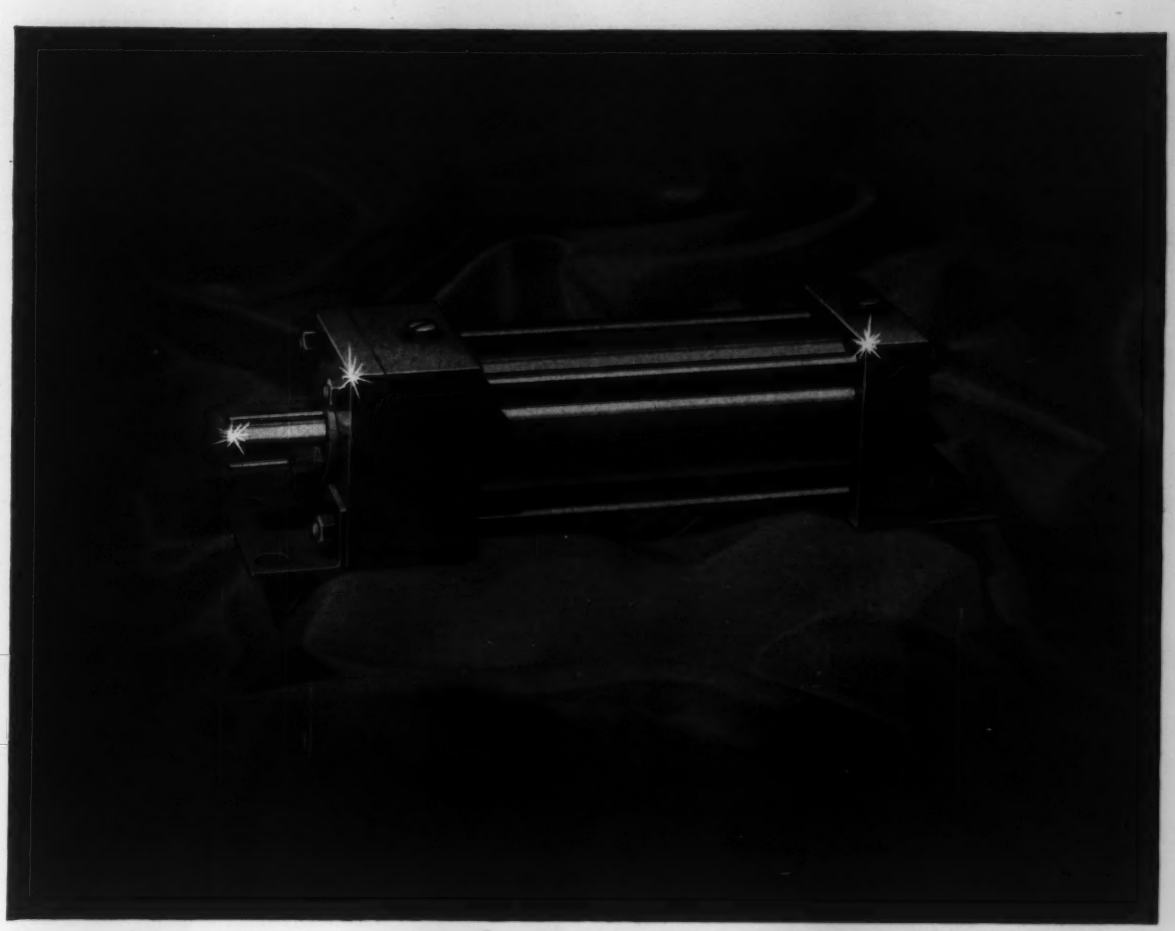
CHR products include:

COHRlastic Aircraft Products — *Airframe and engine seals, firewall seals, coated fabrics and ducts*
COHRlastic Silicone Rubber Products — *Silicone rubber moldings and extrusions, silicone rubber sheets, silicone sponge rubber*
Temp-R-Tapes — *Pressure sensitive, thermal curing Teflon and silicone tapes*
Allied Products — *COHRlastic silicone cements and conductive gasketing*

Leader In Fabrication of Silicone Rubber

CONNECTICUT HARD RUBBER COMPANY

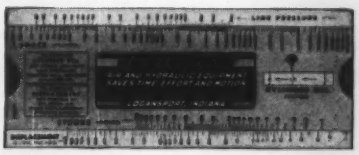
Main Office: New Haven 9, Connecticut



Illustrated—Logansquare Cylinder
Meets J.I.C. Standards

Look to Logan

the ultimate in air cylinder design



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A gift to you from Logansport Machine Company upon request.

MEMBER: Natl. Mach. Tool Builders' Assn.; Natl. Fluid Power Assn.

LOGANSPORT MACHINE CO., INC.
811 CENTER AVENUE, LOGANSPORT, INDIANA

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- ☐ 100-2 MILL-TYPE AIR CYLS.
- ☐ 100-3 AIR-DRAULIC CYLS.
- ☐ 100-4 AIR VALVES
- ☐ 100-5 LOGANSQUARE CYLINDERS
- ☐ 100-5-1 ULTRAMATION CYLINDERS
- ☐ 300-2 PRESSES
- ☐ FACTS OF LIFE
- ☐ 200-1 HYD. POWER UNITS
- ☐ 200-2 ROTOCAST HYD. CYLINDERS
- ☐ 200-3 750 SERIES HYD. CYLINDERS
- ☐ 200-4 and 200-7 HYD. VALVES
- ☐ 200-6 SUPER-MATIC CYLS.
- ☐ 300-1 CHUCKS
- ☐ ABC BOOKLET
- ☐ CIRCUIT RIDER

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COMPANY _____

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Circle 446 on Page 19

AMCHEM Information Bulletin

CHEMICAL PREPAINT TREATMENTS FOR METAL SURFACES

What they do, the types available, how they are applied

By J. H. GEYER, Manager, Product Development Dept., AMCHEM PRODUCTS, INC.

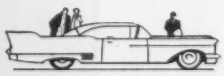
Paint systems have been steadily improved in an effort to produce more decorative, easier-to-apply, and more corrosion-resistant films. The ability, however, of any paint film to perform its predetermined functions cannot be fully utilized without properly preparing the metal surface.

Chemical *prepaint* treatments are designed to do four jobs and do them well. First, they remove organic soils, shop dirt, scale, and rust or corrosion products from the metal surface. Second, they provide surfaces that are completely compatible with subsequent paint films. Third, they produce a *tooth* that promotes good paint film adhesion. Fourth, they effectively prevent underpaint corrosion growth after any breakthrough in the paint film.

Basically, there are four types of chemical prepaint treatments—phosphoric acid, iron phosphate, zinc phosphate, and amorphous phosphate or chromate.

Phosphoric Acid—Phosphoric acid cleaner combination materials are an example of economical chemical prepaint treatments. Amchem Deoxidine is such a material. It removes organic soils, rust, scale and contaminating elements from the metal surface. It also produces a light etch on steel, aluminum or zinc surfaces which considerably aids in increasing paint adhesion. It does not, however, form an actual coating on the metal surface. Any breakthrough in the subsequent paint film will permit underfilm corrosion to proceed. Grades of Deoxidine are available for application by brush or swab, hot and cold dip, or hot spray.

Iron Phosphate—Iron phosphating processes are extensively used in the chemical prepaint treatment of appliances—water heater shells, ranges, washers, dryers and other *white lines*. These processes will produce excellent paint-bonding films on the metal and retard or prevent underpaint corrosion. Duridine, Amchem's iron phosphating process, is a combination organic soil cleaner and iron phosphate coating material. Both the cleaning and coating operations take place in the same bath. Duridine and other iron phosphates do not lend themselves to brush-on application, are primarily designed for spray type equipment of four or five stages. But several dip installations are successfully operating today by inclusion of an alkali precleaning stage.



Zinc Phosphate—Amchem Granodine is an example of zinc phosphating, the type now being used to treat steel in the automotive industry, and predominantly specified for steel ordnance and military items. This process forms a coating which offers the ultimate in paint adhesion promotion and vastly augments the corrosion resistance of subsequent paint films. Zinc phosphate materials are extremely flexible as to method of application—can be applied by brush, dip or automatic spray equipment. In a typical dip or power spray system, the stages would be alkali clean, water rinse, zinc phosphate treatment, water rinse, acidulated final rinse. If the metal has considerable areas of rust or scale, an acid pickle is advisable following the alkali cleaning stage.

On zinc surfaces, the zinc phosphates perform a rather unique function. They act as a barrier against chemical reaction between the applied paint film and the zinc surface. This effectively prevents blistering of the paint and early breakdown of the film. This is in addition, of course, to the improvement of paint adhesion and the retarding of underpaint corrosion. Amchem Lithoform is specially designed for use over zinc surfaces and finds wide application as a prepaint treatment for ornamental zinc die castings, refrigerator liners, and on most galvanized work requiring painted finishes.

Amorphous Phosphate and Chromate—These coatings are the films produced by the Amchem Alodine processes and similar ones on aluminum surfaces. They have met with wide acceptance in the prepaint treatment of venetian blind strips, refrigerator liners, aluminum heat transfer units, aircraft sheet metal assemblies, and many other items fabricated from aluminum. The various coatings provide an excellent film for the promotion of paint adhesion and effectively prevent underfilm corrosion. As in the case of zinc, aluminum exhibits a tendency to chemically react with some paint systems. The Alodine processes develop a barrier film between the paint and the aluminum surfaces which prevents this reaction. The Alodines are extremely versatile materials that can be applied to aluminum surfaces by brush, hand spray, dipping, or mechanical spraying. Brush application is particularly well adapted to the processing of parts too large for simple dip systems or in manufacturing operations that do not warrant a tank setup. In dip or spray application, the system usually consists of an alkaline preclean, a water rinse, the Alodine treatment, a water rinse, and an acidulated final rinse. Where the surface is heavily oxidized, a deoxidizer in the line is needed.

For more complete information about any one or all of these chemical conversion coatings, contact an Amchem sales representative or write us at Ambler 18, Pa.

AMCHEM PRODUCTS, INC. (Formerly American Chemical Paint Co.)

AMBLER 18, PA. • Detroit, Mich., St. Joseph, Mo., Niles, Calif., Windsor, Ont.

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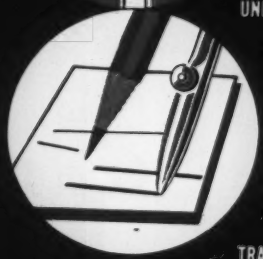

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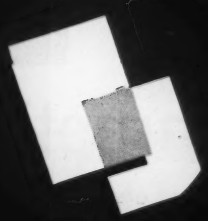

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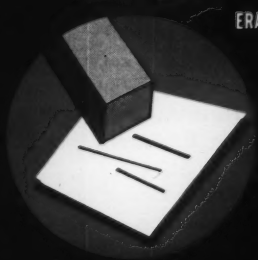

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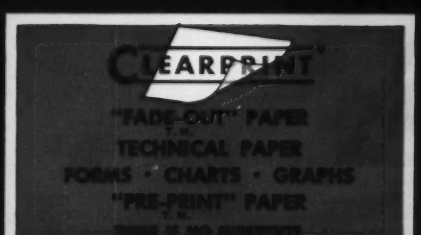

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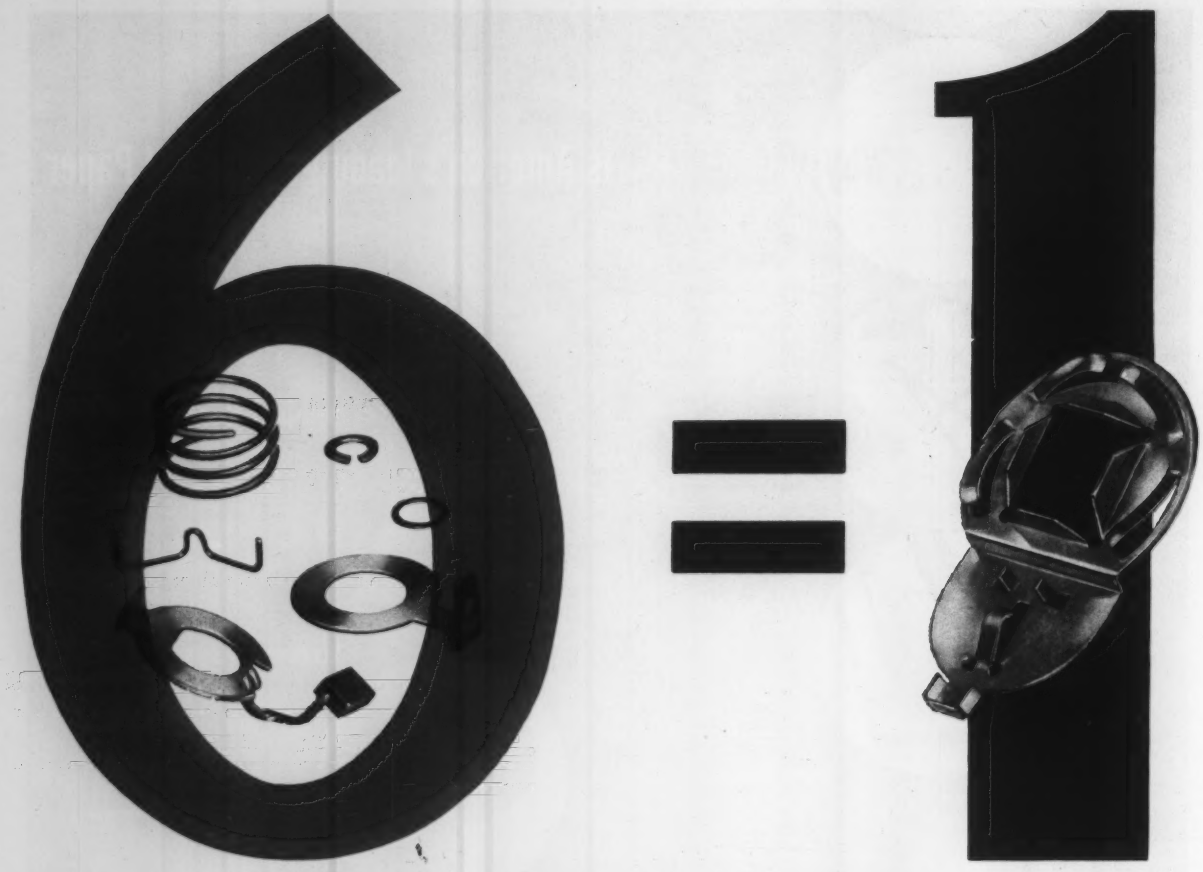
Clearprint Sample Catalog and prices available on request.

Clearprint Paper Company, 1482-67th St., Emeryville, California



with re-design 'rithmetic

One flat spring now does the work previously required of the six parts shown—and greatly simplifies assembly, too. This single multi-purpose spring (a) holds a carbon brush in a rheostat, (b) applies pressure on the wire windings, (c) provides friction detent action, (d) acts as a retainer on the rotating shaft.

How did this come about? The maker of the rheostat undertook a complete redesign analysis, called in an A.S.C. Spring Engineer when it concerned the spring.

Early consultation with A.S.C. springmakers in new or redesign projects gives greater range to plans, safeguards against high production costs. Our booklet, "Designing Springs for Performance," may help you. Write for your copy.

5402

Associated Spring Corporation

General Offices: Bristol, Connecticut

Wallace Barnes Division, Bristol, Conn. and Syracuse, N. Y.
B-G-R Division, Plymouth and Ann Arbor, Mich.
Gibson Division, Chicago 14, Ill.
Milwaukee Division, Milwaukee, Wis.
Raymond Manufacturing Division, Corry, Penna.
Ohio Division, Dayton, Ohio
F. N. Manross and Sons Division, Bristol, Conn.
San Francisco Sales Office, Saratoga, Calif.
Seaboard Pacific Division, Gardena, Calif.
Cleveland Sales Office, Cleveland, Ohio
Dunbar Brothers Division, Bristol, Conn.
Wallace Barnes Steel Division, Bristol, Conn.

Canadian Subsidiary: Wallace Barnes Co., Ltd., Hamilton, Ont. and Montreal, Que. Puerto Rican Subsidiary: Associated Spring of Puerto Rico, Inc., Carolina, P.R.

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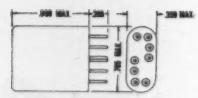
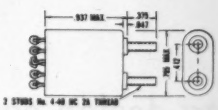
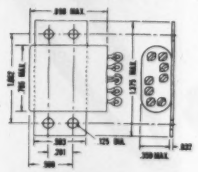


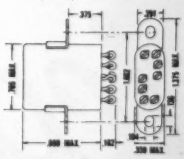
SC11D
6, 12, 24, 36 Volts



SC11DK
6, 12, 24, 36 Volts



SC11DB
6, 12, 24, 36 Volts

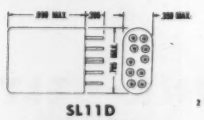


SC11DA
6, 12, 24, 36 Volts

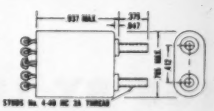
SC

2 TYPES • 4 MOUNTINGS • 4 VOLTAGES

SL



SL11D
6, 12, 24, 36 Volts



SL11DK
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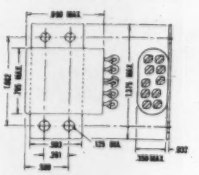

SL11DB
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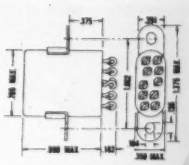
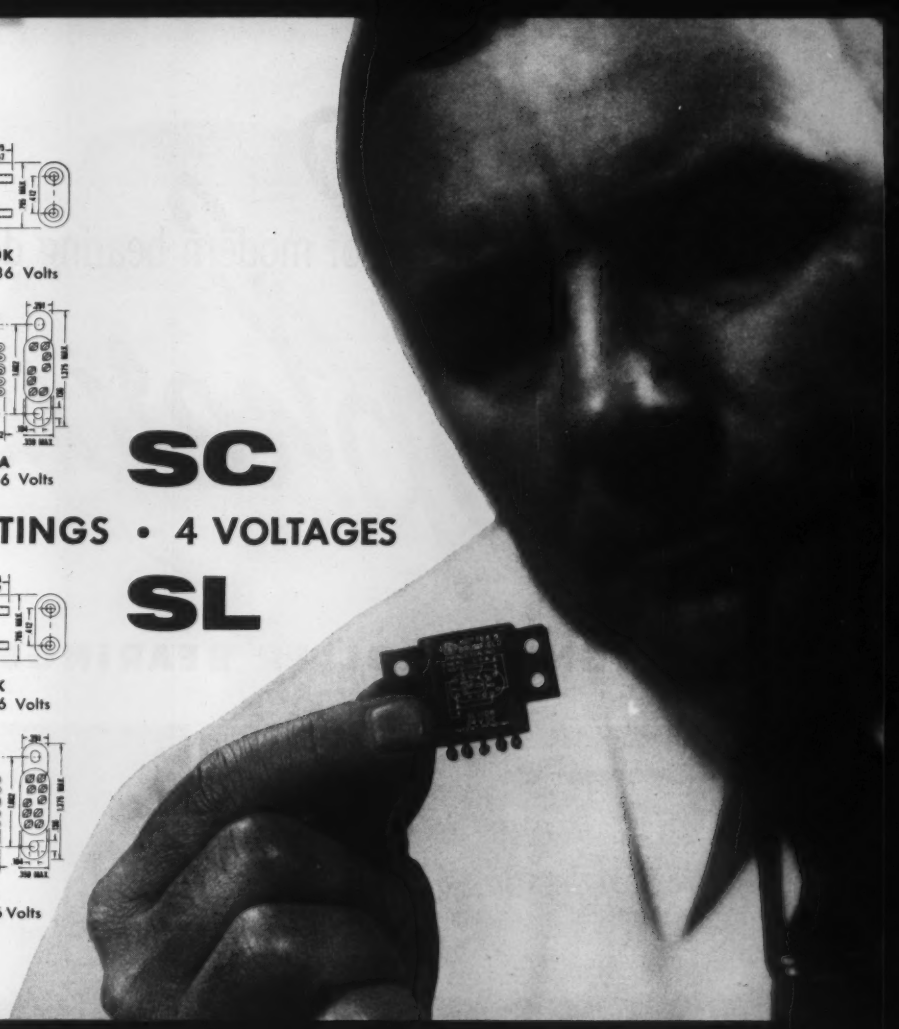


SL11DA
6, 12, 24, 36 Volts



Off the shelf delivery FROM YOUR P&B DISTRIBUTOR

32 STANDARD P&B CRYSTAL CASE RELAYS

Prototype or small-production-run quantities of P&B's micro-miniature relays are now available from your local electronic parts distributor. Choose from 2 types, 4 mountings, 4 coil voltages—32 models in all.

P&B's dual coil, permanent magnet, crystal case relays remain operative under 100g shock, 30g to 2000 cps vibration. Modern White Room production facilities assure highest possible reliability.

The SC conforms to standard dimensions and circuitry, and can replace ordinary relays of the same size.

The SL, a latching relay, utilizes the dual-coil, permanent magnet principle to provide a highly efficient, tenacious latch, assuring high contact pressure.

Order today from your local electronics parts distributor.

SC and SL SPECIFICATIONS:

Shock: 100g for 11 millisec.

Vibration: 30g from 55 to 2000 cps
.195" max. excursions from 10 to 55 cps

Ambient Temperature Range:
—65°C. to +125°C.

Contact Arrangement: dpdt

Contact Load: 2 amps at 30 vdc
1 amp at 115 vac, 60 cycle

Sensitivity:
SL—230 milliwatts at 25°C. with 630 ohm coil
SC—260 milliwatts at 25°C. with 550 ohm coil

POTTER & BRUMFIELD

DIVISION OF AMERICAN MACHINE & FOUNDRY COMPANY, PRINCETON, INDIANA

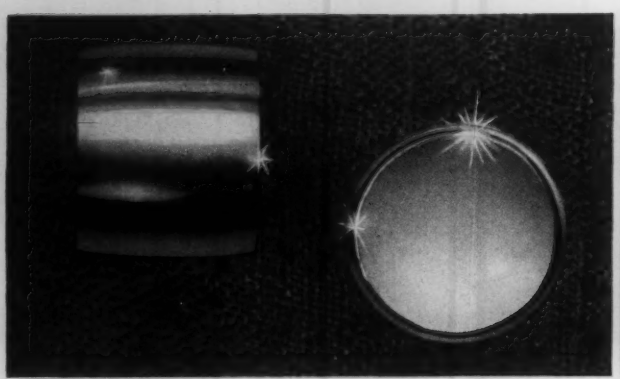
IN CANADA: POTTER & BRUMFIELD CANADA LTD., GUELPH, ONTARIO

Circle 450 on Page 19

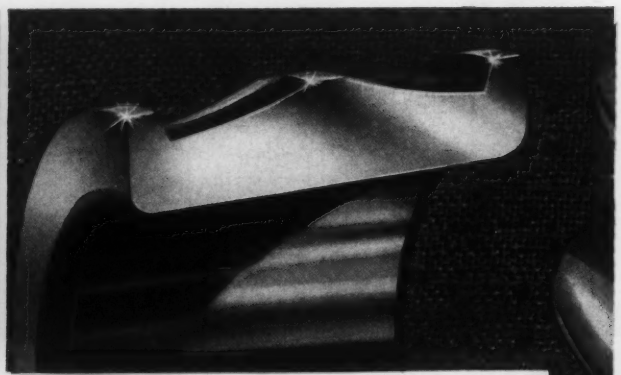
News! The best features of modern bearing design combined

Spherical

SELF-ALIGNING ROLLER BEARINGS BY LINK-BELT



BIG, HIGHEST-CAPACITY ROLLERS. Each bearing has a maximum number of rollers—as large as possible, yet all components are in optimum balance. Precision-ground to extreme accuracy, these convex rollers offer maximum economy for all applications.



HIGH, HEAVY INNER RACE FLANGES. Hefty inner race has sturdy shoulders which offer convenient hold for assembly and removal of bearing. They end problems of cutting away shaft or applying pressure at outer race . . . avoid any need to skimp on shaft shoulders.

BIG, mirror-smooth convex rollers *plus* heavy, broad-shouldered inner race *plus* centrifugally-cast bronze, precision-machined retainer! Only from Link-Belt do you get ALL that is best in bearing design.

Individually, these elements represent major improvements on accepted design concepts. Collectively, they constitute the most efficient spherical roller bearings available . . . promise unequalled economies, whatever the application. Men who know bearings will readily recognize new contributions to capacity, endurance and ease of maintenance.

For the good of your equipment, take time for a feature-by-feature comparison with any bearings you're now using. Your Link-Belt office will gladly explain the many performance advantages evolved with this new design. It can furnish full data on industry's most complete line of ball and roller bearings . . . pillow blocks and flanged, flanged cartridge, cartridge and take-up blocks.

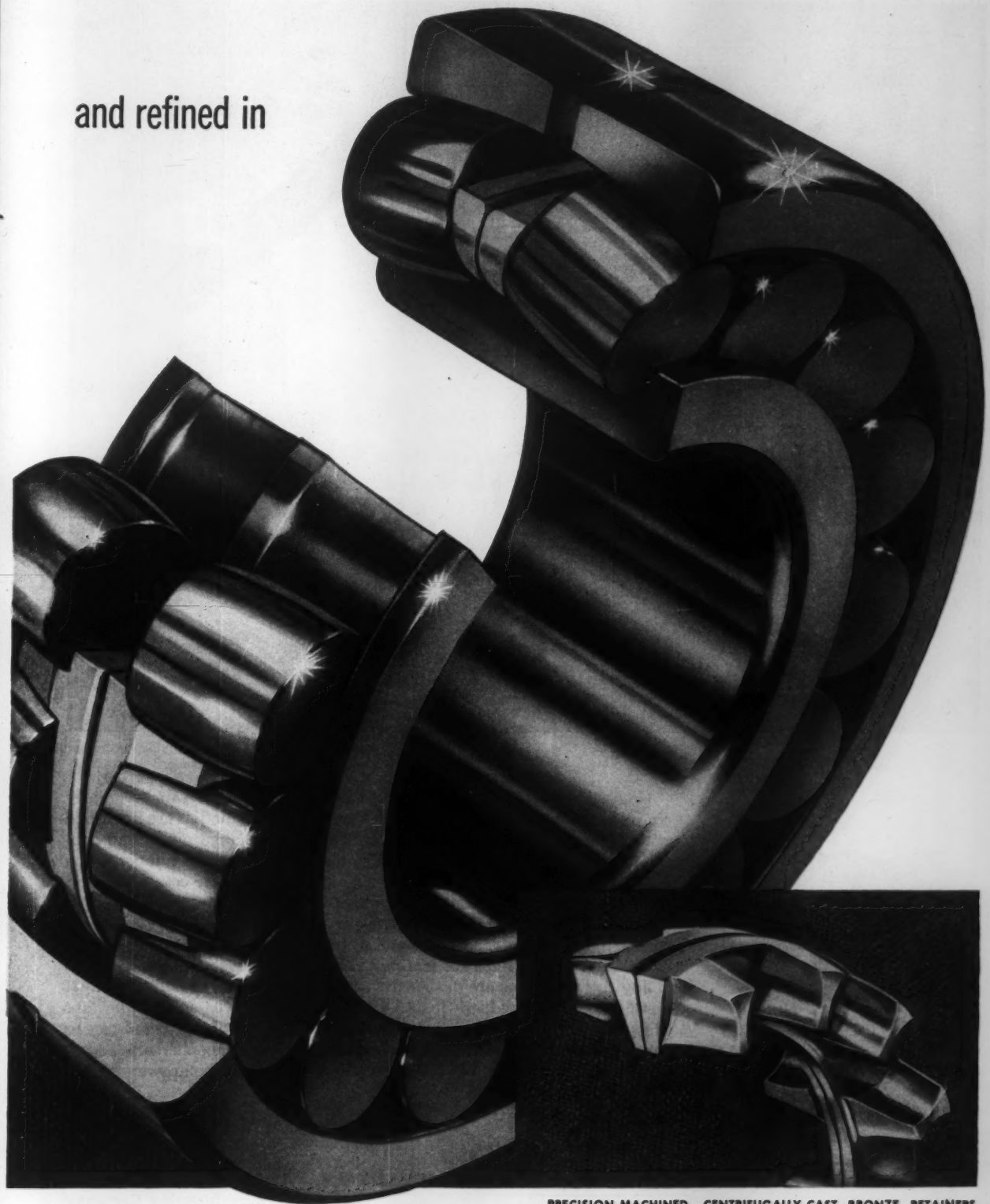
LINK BELT

MANUFACTURER OF SELF-ALIGNING BALL AND ROLLER BEARINGS

LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Sales Offices and Stock Carrying Distributors in All Principal Cities. Export Office: New York 7; Canada, Scarboro (Toronto 13); Brazil, Sao Paulo; Australia, Marrickville (Sydney), N.S.W.; South Africa, Springs. Representatives Throughout the World.

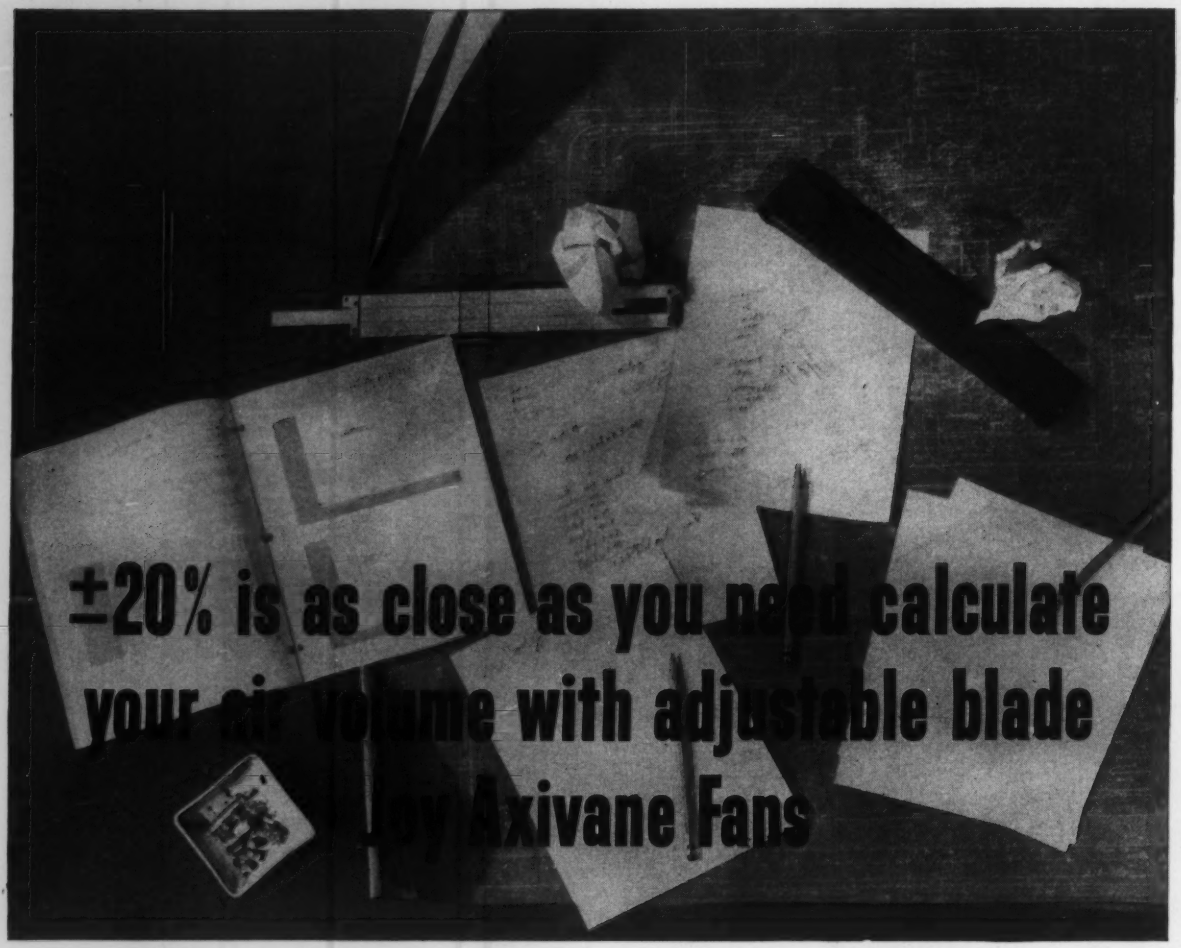
14.818-A

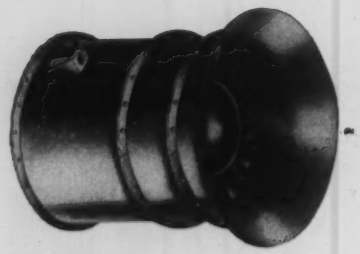
and refined in



PRECISION-MACHINED, CENTRIFUGALLY-CAST BRONZE RETAINERS offer many times more support and ability to withstand high stress. They are not stampings—they space rollers accurately under extreme speeds and loads. Independent cage action for each row of rollers assures maximum bearing efficiency.

Circle 451 on Page 19





Ask for Bulletin 290-64B.

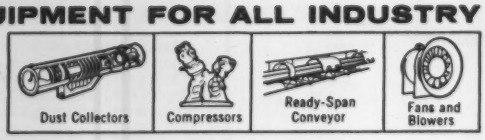
Computation of air volumes required for ventilation can be greatly simplified by installing Joy Axivane Fans. Standard models are furnished with adjustable blades which can be rotated to change pitch, and consequently volume, over a considerable range. This permits compensating for circumstances unforeseen when air requirements were computed, and also allows the installation of fans which will be able to efficiently supply additional air for pre-planned expansions of the plant. Blade adjustments can be made by anyone in a matter of minutes. Calibrated scales on hub and blades assure accurate matching of blade pitches.

Joy Axivane Fans are designed with integral motors to permit in-duct installation. This reduces installation costs, and saves space. The fans are available in a wide range of sizes for every type of duty, and can be furnished in special materials for use in corrosive atmospheres.

Whatever your fan requirements may be, Joy has the answer.

WSW I 7483-290

AIR MOVING EQUIPMENT FOR ALL INDUSTRY



JOY

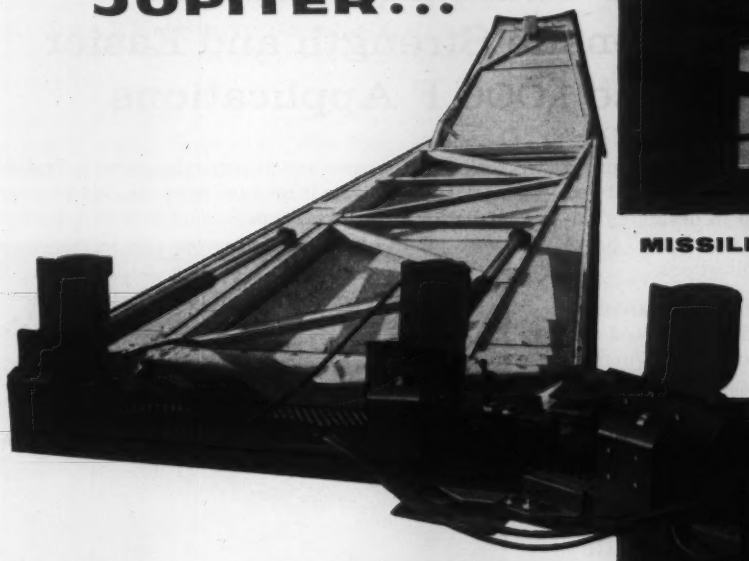
Joy Manufacturing Company
Oliver Building, Pittsburgh 22, Pa.

In Canada: Joy Manufacturing Company (Canada) Limited, Galt, Ontario

Circle 452 on Page 19

HURRICANE-PROOF "OVERCOAT" FOR THE JUPITER...

MISSILE SHELTER-PANELS RAISED



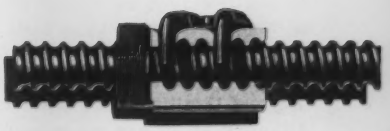
MISSILE SHELTER-PANELS OPEN

"buttoned up" by 24 Saginaw b/b Screws

Buttoning up the "overcoat" for the Jupiter IRBM is a cinch for the Saginaw Ball Bearing Screw! The "overcoat" is a portable prefab standby shelter designed by Barnes & Reinecke, Chicago, and U. S. Army Engineer Research and Development Laboratories, Fort Belvoir, Va., to protect the missile's tail and personnel working on it. The shelter has 12 base sections with hinged panels raised electrically to form a weather-tight seal around the Jupiter's hull.

The Saginaw b/b Screw converts *rotary* motion into *linear* with over 90% *efficiency*. This enables the Saginaw Screws to dependably raise or lower these panels—and hold the shelter securely in place—even in the face of 76 mph hurricane winds. In fact, each Saginaw Screw is able to withstand a combined wind and weight stress of almost five tons! The Saginaw Screw also offers substantial savings in space, power and weight which make the shelter easier to transport and assemble.

The Saginaw Screw may be able to give *your* products that valuable Sales Appeal you're looking for. To find out, write or telephone Saginaw Steering Gear Division, General Motors Corporation, Saginaw, Michigan—*world's largest producers of b/b screws and splines.*



Give your products NEW SALES APPEAL... switch to the **Saginaw** ball bearing **Screw**

WORLD'S MOST EFFICIENT ACTUATION DEVICE

Memo on Metals

New Age-hardenable Titanium Alloys Offer Up to 220,000 psi Tensile Strength and Easier Formability for 600 to 1,000 F Applications

Three new age-hardenable titanium alloys may prove to be the solution to many of the strength-weight and temperature problems encountered in designing advanced aircraft and missiles. They may also prove extremely economical for such applications.

All three offer much higher strengths than other titanium alloys – and have the light weight and corrosion resistance typical of titanium alloys. Furthermore, they are readily FORMAGEABLE* – capable of being formed in the solution-treated or "soft" condition and then strengthened by simple thermal aging techniques. Each is now in pilot production and available in limited quantities of mill products.

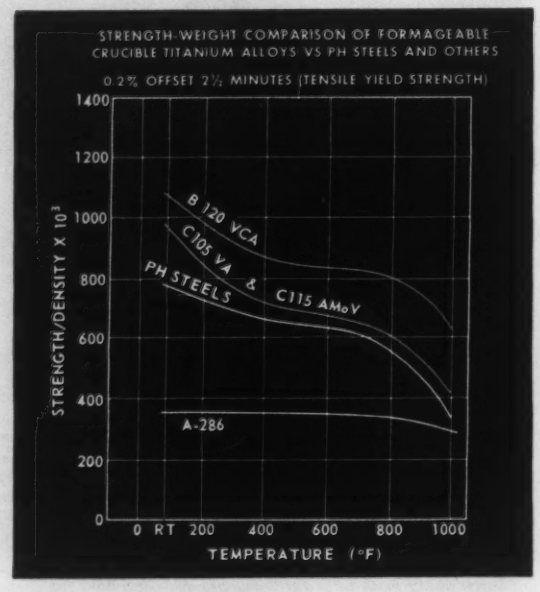
First Age-hardenable All-beta Ti Alloy

Crucible B-120VCA is the first useful titanium alloy with an all-beta (high temperature) structure. It has both the highest strength and best formability of any titanium-base alloy.

This alloy's composition (13%V-11%Cr-3%Al) enables its structure to stay all-beta during forming and/or during slow cooling, and to age to high strength levels at temperatures where distortion is not a problem.

B-120VCA has a unique combination of properties. Room temperature strengths of 200,000 to 250,000 psi have been obtained. On a strength-weight basis this is the highest strength of any available structural material. In short-time elevated temperature tensile tests (1-2 minutes), it offers a decided strength-weight advantage over alternate materials at temperatures up to at least 1,000 F. Under creep conditions, for very long periods of time, it enjoys a strength-weight advantage up to at least 600 F. Beyond this limit, the other Crucible FORMAGEABLE titanium alloys are recommended.

B-120VCA is ductile-weldable, cold-headable, and has great and deep hardenability. Because of this formability, it should prove suitable for applications such as aircraft skins, stiffeners and other primary structural shapes, and for missile pressure tanks, rocket motor cases and structural members. Preliminary tests indicate it may prove unequalled as a construction material for honeycomb assemblies. Because it is so easy to cold-head, it has a large potential in such items as rivets.



Alpha-beta Titanium-base Alloys

Crucible C-105VA is an alph-beta titanium-base material which also is FORMAGEABLE. Its 16% vanadium content stabilizes a sufficient amount of the beta phase for good age-hardenable response; the 2.5% Al content improves the alloy's elevated temperature properties.

C-105VA resolves two conflicting requirements for aircraft sheet material. It is soft, ductile and easily formed in the solution-quenched condition. Because the formed parts can be aged subsequently at moderate temperatures, parts made of C-105VA can possess high strengths at temperatures up to 800 F for long periods of time.

* *age-hardenable titanium alloys*
* *tool steels in production parts*
* *borated stainless steels*

This third alloy, C-115 AMoV (4%Al-3%Mo-1%V), also shows considerable promise for aircraft sheet applications. It is age-hardenable to higher strengths than C-105VA with only slight sacrifice in forming characteristics.

Considerable data on the properties and fabricating qualities of all three alloys have been assembled by Crucible's Titanium Division. For data sheets and additional information, send the coupon.

Tool Steels Replace Standard Alloys for Production Parts

As design and metallurgical engineers require materials with improved properties or greater uniformity, they are turning more to the use of tool steel for production parts. Here are three good examples:

1. Vanes in the hydraulic system that actuates the automatic steering mechanism on cars are made of Crucible REX® M-2 high speed steel. REX M-2 combines the abrasion resistance necessary for minimum wear with the impact resistance needed for long life and safety. The manufacturer experimented with numerous other steels, but high speed steel lasted longer than any other type tested.

2. Actuator bars for a nationally-known calculator are now being produced of Crucible KETOS® – a low-priced AISI Type O1 alloy tool steel – because the thin, close-tolerance contact edges withstood over 4-million high speed blows in a life test. No other steel has lasted more than 1-million cycles before chipping and failing.

3. Cylinder block for a fast acting, aircraft hydraulic pump made of Crucible Chrome tool steel. Pump operates at temperatures up to 500 F, pressures to 5,000 psi. Tool steel was selected over a standard AISI alloy because of its high degree of cleanliness, uniform response to heat treatment, and controlled hardenability. Furthermore, because tool steel practices are employed in making it, the steel more consistently meets the critical mechanical and physical properties required in this application.

For data sheets on these and all other Crucible tool steels – send the coupon.

High Boron Stainless Steels Made Possible by Vacuum Melting

Type 304 stainless steel with boron has proved to be an excellent material for nuclear equipment, because the boron readily absorbs neutrons. By increasing the boron content, valuable weight and thickness reductions can be made in reactor shielding and control rods.

Unfortunately, conventionally melted borated 304 becomes "hot short" – virtually impossible to work if the boron content exceeds 1%. Vacuum melting has provided the answer to this problem. Vacuum-melted 304 stainless is readily workable when the boron content goes up to 2% or even higher.

Vacuum melting the alloy also provides closer control of the composition, because only pure materials are used. So, undesirable elements such as cobalt – which becomes radioactive upon bombardment – can be kept to a minimum. In fact, vacuum-melted Type 304 stainless can be supplied with less than .001% cobalt.

For additional information on vacuum-melted steels – send the coupon.

CRUCIBLE STEEL COMPANY OF AMERICA
Dept. EH-07, The Oliver Building
Mellon Square, Pittsburgh 22, Pa.

Gentlemen:
Please send me the following:

1. Data sheets on B-120VCA ☐ C-105VA ☐ C-115AMoV ☐
2. A copy of "Titanium Alloys for Aircraft and Spacecraft" by Finlay, Vordahl and Malone ☐
3. Data Book on Crucible tool steels ☐
4. Data sheets on vacuum-melted steels ☐

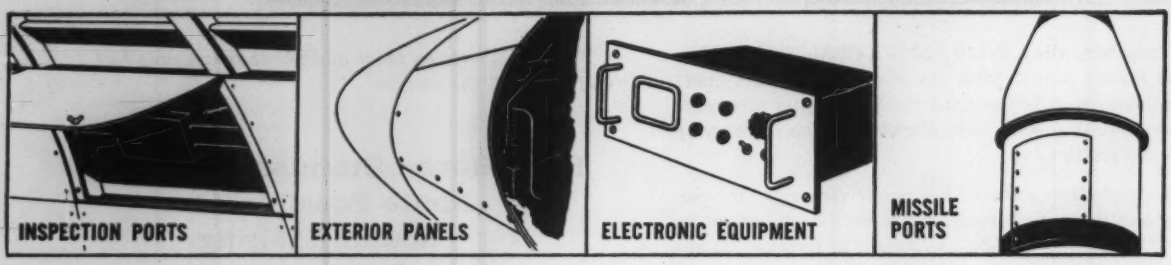
Name_____ Title_____
Company_____
Street_____
City_____ Zone____ State_____

CRUCIBLE STEEL COMPANY OF AMERICA

*Reg. Trade Mark

FLIGHT-PROVED RELIABILITY . . .

LION *Quarter-turn* FASTENERS FOR SECURING REMOVABLE SECTIONS



Southco's Lion Quarter-turn Fasteners provide quick access and reliable securing of hinged or completely removable panels. Resistance to severe heat, shock and vibration, and a high strength-weight ratio make these unique fasteners ideal for use in private, commercial or military aircraft and missiles . . . for ground production and control or airborne applications.

Lion Fasteners consist of three parts . . . a one-piece, swaged-nose stud; a retainer; a floating receptacle which is riveted or welded in place. Installation requires no special tools . . . is simplified by a permissible float of .070".

SWAGED NOSE

Case hardened one-piece stud with swaged nose has no milled sections, inserts, or cross pins . . . requires no wire spring to hold it in locked position. Lion Fasteners offer the highest weight-strength ratio available.

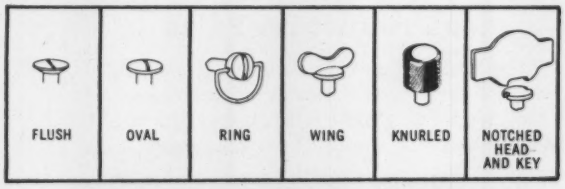
2 TYPES AVAILABLE

LION NO. 2 FASTENER
For use where space is limited and where weight must be kept at a minimum.

LION NO. 5 FASTENER
For heavy-duty applications where good tensile and shear strength are required.

FULL RANGE OF HEADS

Lion No. 2 Fastener available with flush, oval or wing type. No. 5 with flush, oval, ring, wing, knurled or notched head and key.



OTHER SPECIFICATIONS

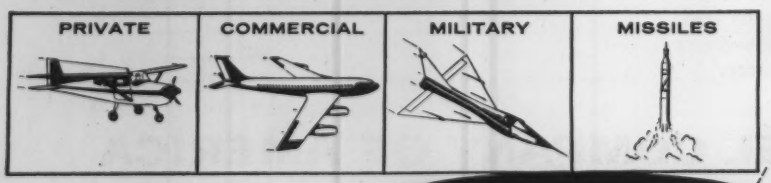
LION NO. 5 QUARTER-TURN FASTENERS CONFORM TO MIL. SPEC. MIL-F-5591A (ASG) . . . ARE ON THE GOVERNMENT'S QPL . . . ARE CAA APPROVED FOR COMMERCIAL AND PRIVATE AIRCRAFT USE.

MATERIAL: Cadmium-plated case-hardened steel.

FREE!

FASTENER HANDBOOK

Send for your free copy of Southco Fastener Handbook No. 8. Gives complete engineering data on Lion Fasteners and many other special fasteners. Write to Southco Division, South Chester Corporation, 237 Industrial Highway, Lester, Pa.



LION *Aviation* FASTENERS

one of the SOUTHCO FASTENERS LION

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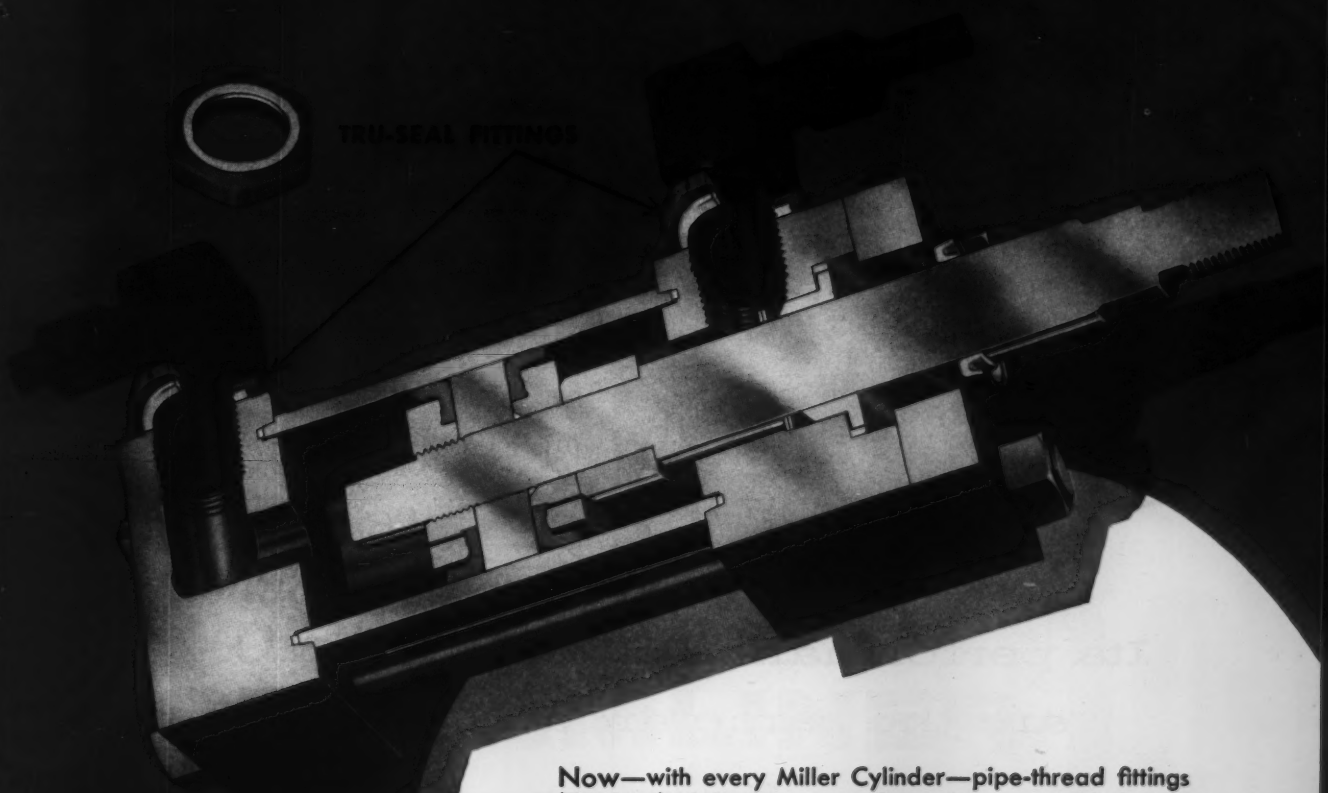
Circle 454 on Page 19

NOW... even the PORTS have seals of the PRESSURE SEALING TYPE!



Now—with every Miller Cylinder—pipe-thread fittings (Tru-Seal) of the *pressure sealing type* are provided *at no extra cost* for sealing the cylinder ports.

Additional advantages of these fittings are:

1. All circuit piping and fittings can be easily positioned.
2. Damage to equipment caused by high tightening torque is completely eliminated (especially on valves, pumps, etc.)
3. Sealing material is Teflon, which is compatible with all hydraulic fluids (J. I. C. Standard H6.2.1)

Specify

Miller

for Greater Reliability

Engineering Bulletins on Miller Air and Hydraulic Cylinders Available on Request

MILLER FLUID POWER

DIVISION OF BUCK-MILLER CORPORATION

7N016 YORK ROAD, BENSENVILLE, ILL.

Wherever your customers buy ALVANIA...

Its performance and name are the same around the world

Other Outstanding Shell Industrial Lubricants

Shell Tellus Oils—for hydraulic systems

Shell Talona R Oil 40—anti-wear crankcase oil for diesel locomotives

Shell Rimula Oils—for heavy-duty diesel engines

Shell Turbo Oils—for utility, industrial and marine turbines

Shell Dromus Oils—soluble cutting oils for high-production metal working

Shell Macoma Oils—for extreme pressure industrial gear lubrication

Shell Voluta Oils—for high-speed quenching with maximum stability

SHELL ALVANIA GREASE is available world-wide . . . assurance that your customers abroad will get the same performance from your equipment that domestic customers rely upon.

You can count on Alvania® Grease to remain plastic in sub-zero weather and, equally important, to remain stable under sustained high temperatures. On job after job, Shell Alvania Grease has successfully replaced dozens of special lubricants.

Alvania Grease also has an outstanding performance record on the toughest anti-friction bearing grease applications. It is ideal for wet, humid applications because it is inhibited to prevent water corrosion. It gives good lubrication under conditions which normally spell trouble.

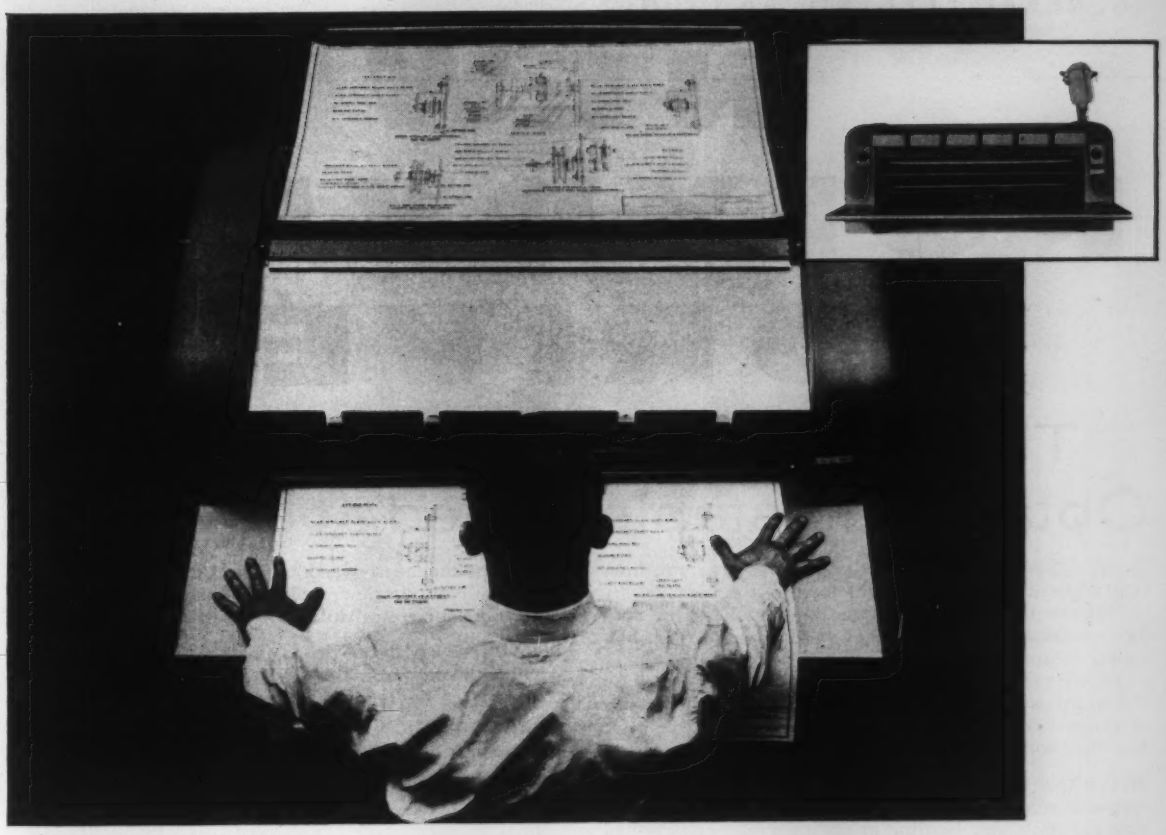
For complete information on this truly multi-purpose grease, write Shell Oil Company, 50 West 50th Street, New York 20, New York, or 100 Bush Street, San Francisco, 6, California. In Canada: Shell Oil Company of Canada, Limited, 505 University Avenue, Toronto 2, Ontario.

SHELL ALVANIA GREASE

the truly multi-purpose lubricant

SHELL

Circle 456 on Page 19



Announcing . . .
Ozalid's new 30-inch
STREAMLINER 100

Now you can have a compact table-top whiteprinter with "big machine" features at a slim-budget price. And you can enjoy the convenience of on-the-spot printmaking round the clock. Make all the prints you need, inexpensively and without delay. There's no make-ready or cleanup . . . anyone can learn to use the 100 in minutes. Check these important features:

- Makes prints up to 30" wide by any length
- Front and rear print stacking
- Simple dry-developing system
- Easy turn-on, turn-off controls
- Smooth-running electronic drive with speeds up to 14 fpm
- Hook-on tracing receiving tray (optional at extra cost)

And the versatile Streamliner 100 handles the whole range of Ozalid sensitized materials . . . lets you turn out gum-backed labels, photographs, cloth maps, or color transparencies!

For complete details on the new Streamliner 100, mail coupon today!

OZALID

Division of General Aniline & Film Corporation
In Canada: Hughes-Owens Co., Ltd., Montreal

Ozalid, Dept. S-8, Johnson City, N. Y.

Please send me free descriptive brochure on the new Streamliner 100.

Name_____

Company_____

Position_____

Street_____

City_____ Zone_____

State_____

Circle 457 on Page 19

GENERAL ELECTRIC ANNOUNCES . . .

NEW POLYDYNE* DRIVE

The Modern Mechanical Way to Obtain Adjustable Speed at Low Cost

General Electric's new Polydyne drives give you low-cost adjustable speed straight from a-c power!

They're compact and versatile—available in configurations and ratings to meet virtually all adjustable-speed requirements!

Polydyne drive versatility is further increased by the number of mounting positions possible, by choice of remote controls, and by speed control and conduit box location.

POLYDYNE DRIVES SUPPLY CONSTANT TORQUE and respond smoothly to load changes. New control design prevents any binding or sticking of speed control mechanisms. All units have been factory and field-tested to help assure dependable operation over long periods of continuous service.

EASY MAINTENANCE. Belt changing is a simple job, and fast! Advanced design reduces possibility of damage to drive shaft and bearings during belt change, and eliminates shaft realignment problems after change.

General Electric Polydyne drives require minimum lubrication, and helical reducer gears can be removed as a unit for easy inspection, service.

Polydyne mechanical adjustable-speed drives can help you boost production by enabling you to:

1. Get the most effective process speed.
2. Get maximum machine life.
3. Adapt machine speed to operator ability.
4. Obtain maximum machine versatility.
5. Synchronize multiple processes.

POLYDYNE RATINGS—¼ to 25 hp, a-c; output speeds 4200 to 5 rpm; frame sizes 1 to 5; speed variations of 2/1 to 10/1 (depending upon frame).

GEAR REDUCTIONS—Single, double, triple and right-angle shaft.

ENCLOSURES—Dripproof and totally enclosed drives.

CONTROLS—Mechanical, manual or remote; electrical pushbutton remote; pneumatic or hydraulic remote.

ACCESSORIES—Remote control with tachometer speed indicator, brakes and slide rails.

CONFIGURATIONS—Upright, horizontal, C, Z, and 45°, geared and non-geared. Non-motorized units also available.

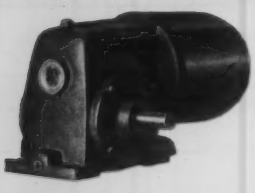
FOR MORE DETAILS and specifications on the complete General Electric PLUS LINE, including Polydyne, contact your nearby G-E Apparatus Sales Office or Distributor, or write for bulletins: Polydyne Drive (GEA-6806), G-E Helical Gear Motor Line (GEA-6704), Shaft-mounted Speed Reducers (GEA-6616), Fractional Horsepower Gear Motors (GEA-6133A), Section 854-1, General Electric Co., Schenectady, N. Y.

*Trademark of General Electric Co.

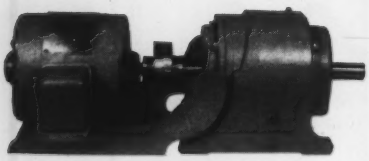
Progress Is Our Most Important Product

GENERAL ELECTRIC

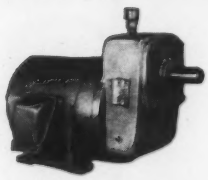
CHOOSE FROM GENERAL ELECTRIC'S **PLUS LINE** OF



Right-angle shaft gear motor



All-motor gear motor



Offset-shaft gear motor

General Electric Polydyne is a complete "packaged" drive consisting of a-c driving motor, belt transmission, output gearing and control.

NOW AVAILABLE FROM STOCK!

You get all these PLUS VALUES with General Electric Mechanical Power Transmission Equipment

1. **Product Application Service.** G-E engineers are available to help you analyze and select the right equipment for your job.

2. **Prompt Shipment.** Offered on all standard General Electric units—from distributor or factory stocks.

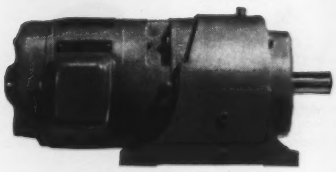
3. **Sales Service.** Your inquiries, quotations and requests for bids are handled promptly by G-E field service offices.

4. **After Sales Service.** 50 G-E Service Shops and 500 authorized Small Motor Service Stations offer expert repair service on all G-E Gear Motor products.

5. **Manufacturer Responsibility.** G.E. focuses manufacturing responsibility at one source, for it produces *all* gearing, components and motors included in its line.

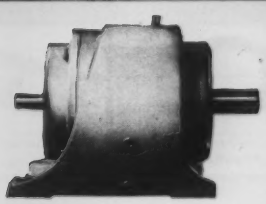
6. **Manufacturer Reputation.** Advanced technology built into G-E mechanical power transmission equipment assures you that it will meet your standards; adds value to and builds preference for your product.

MECHANICAL POWER TRANSMISSION EQUIPMENT



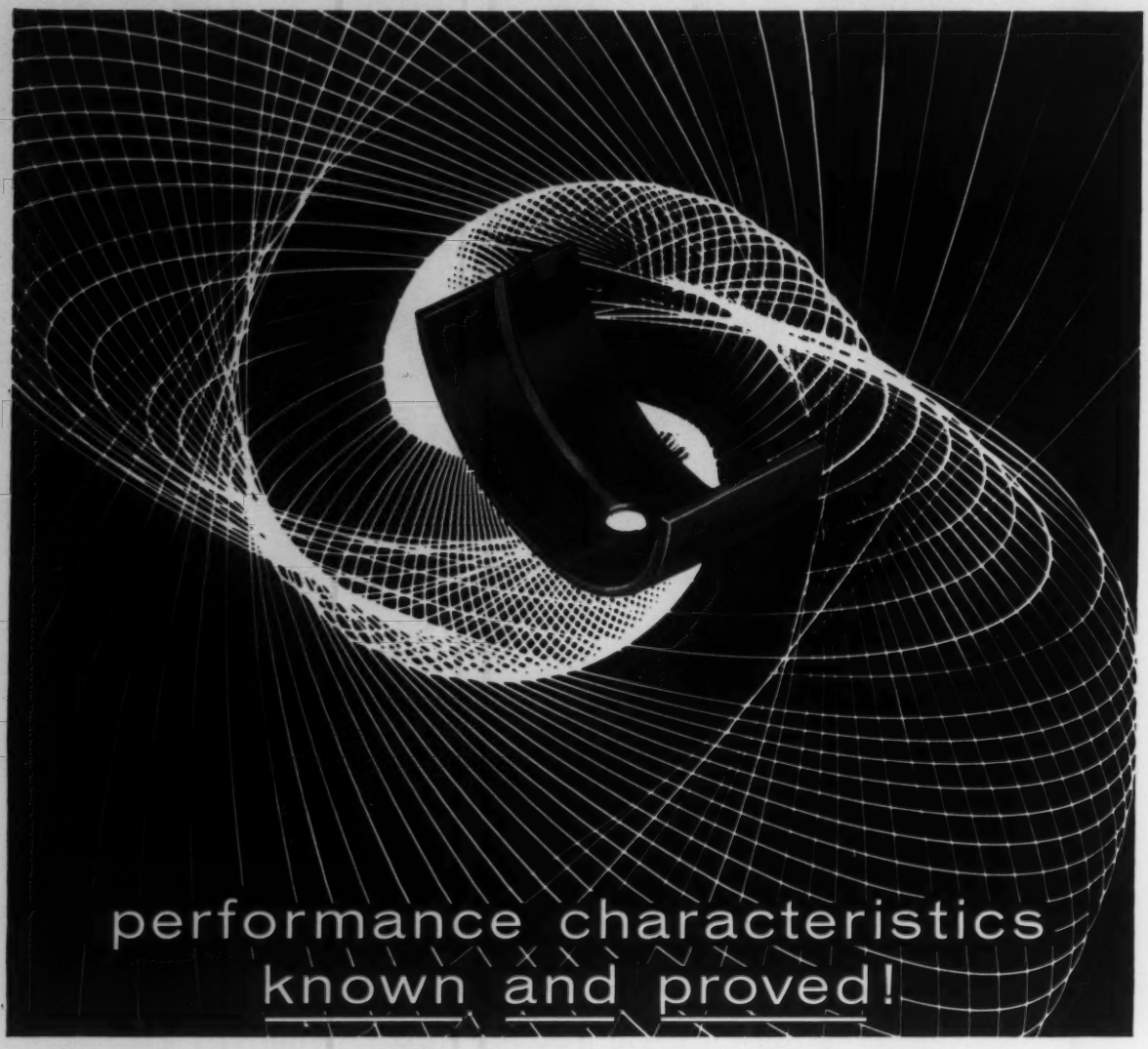
Integral-type gear motor

Shaft-mounted speed reducer



Helical speed reducer

Circle 458 on Page 19



For 60 years, we have designed, tested and proved countless alloy combinations to meet varying individual engine bearing needs.

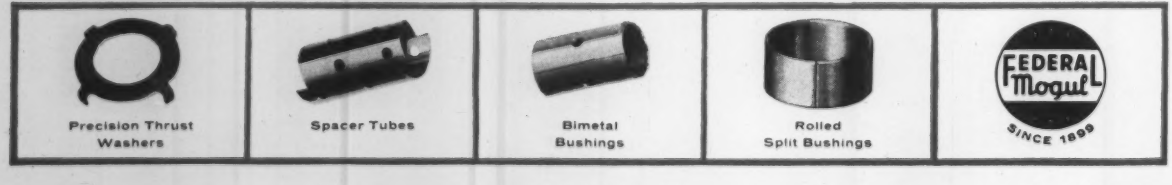
Combined with our quality-controlled, high-volume production, this background is constantly used by leading design engineers with sleeve bearing problems.

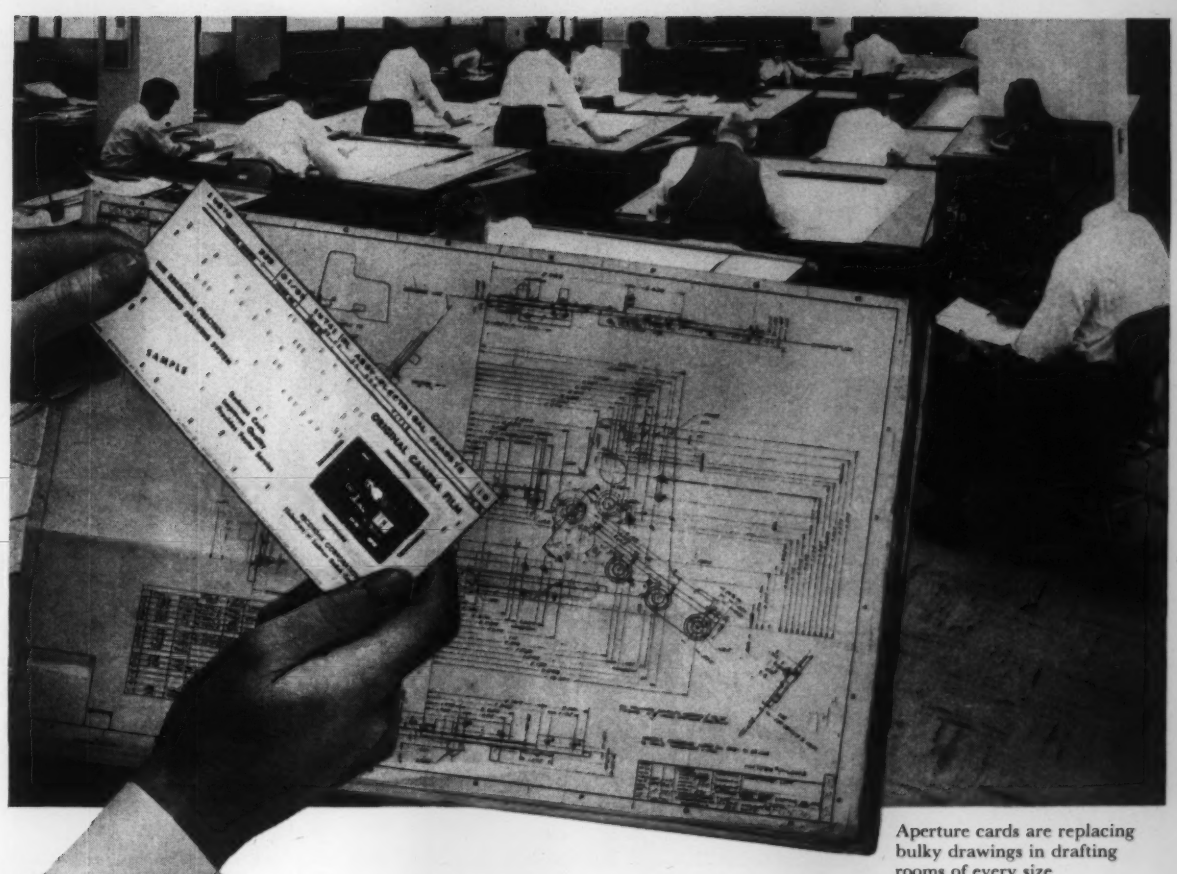
Babbitts, bronzes, copper-leads, aluminums—we've charted and measured their fields of usefulness . . . performance characteristics . . . individual advantages.

This wealth of experience and know-how is available to you for the asking.

FEDERAL-MOGUL DIVISION

FEDERAL-MOGUL-BOWER BEARINGS, INC., 11045 SHOEMAKER, DETROIT 13, MICHIGAN





Aperture cards are replacing bulky drawings in drafting rooms of every size

First step in automating your drawing file:

Sharp, legible pictures on low-cost 35mm Recordak Microfilm

When you automate your engineering drawings—when you turn these bulky records into trim decks of cards—you can count on: 1) Faster reference and communications; 2) Lower blueprint costs; 3) Savings in filing space and equipment; 4) Greater protection.

Your success with this new system depends, first, upon the quality of your microfilm reproductions. They must be completely legible when viewed in film readers; they must also produce accurate, easy-to-read paper prints when needed.

Using the Recordak Precision System, you are assured that your films easily pass the most rigid requirements. For Recordak pioneered the job of reproducing engineering drawings on low-cost 35mm microfilm. Developed controls and standards which assure that drawings and prints of all ages, sizes and colors, are reproduced with remarkable clarity and uniformity.

So step into "automation" with full confidence! Call your local Recordak office or Recordak Microfilming Dealer. No obligation. *"Recordak" is a trademark*

RECORDAK

(Subsidiary of Eastman Kodak Company)

originator of modern microfilming—
now in its 32nd year

.....MAIL COUPON TODAY.....

RECORDAK CORPORATION
415 Madison Avenue, New York 17, N. Y. DD-8

Gentlemen: Send free booklet describing new Recordak Precision Engineering Drawing System. No obligation whatsoever.

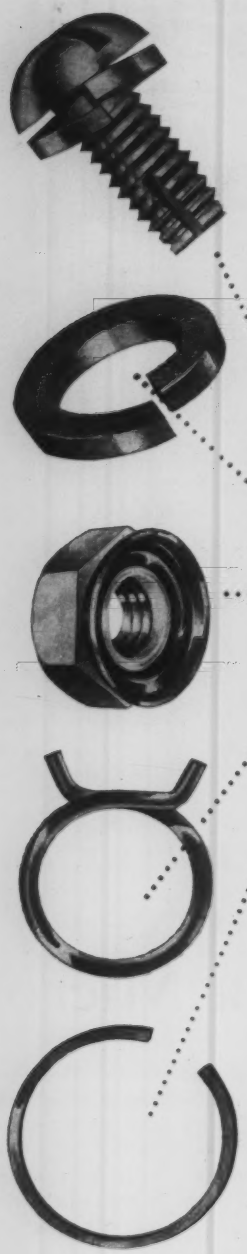
Name_____

Company_____

Position_____

Address_____

City_____ State_____



MORE THAN BASIC

Fasteners are basic. But Eaton-Reliance fasteners do more than just hold parts together — they cut assembly costs, improve product quality, simplify design. Fastener engineering is a highly specialized business. Good fastener engineering can mean the difference between success and failure in the manufacture of your products — between being competitive or priced out of the market — or between enthusiastic approval and just lukewarm acceptance for your products by your customers. If you fasten parts together, it will be worth your while to investigate the Eaton-Reliance line of engineered industrial fasteners. They are top quality. Write for our General Catalog.

EATON

RELIANCE DIVISION

MANUFACTURING COMPANY

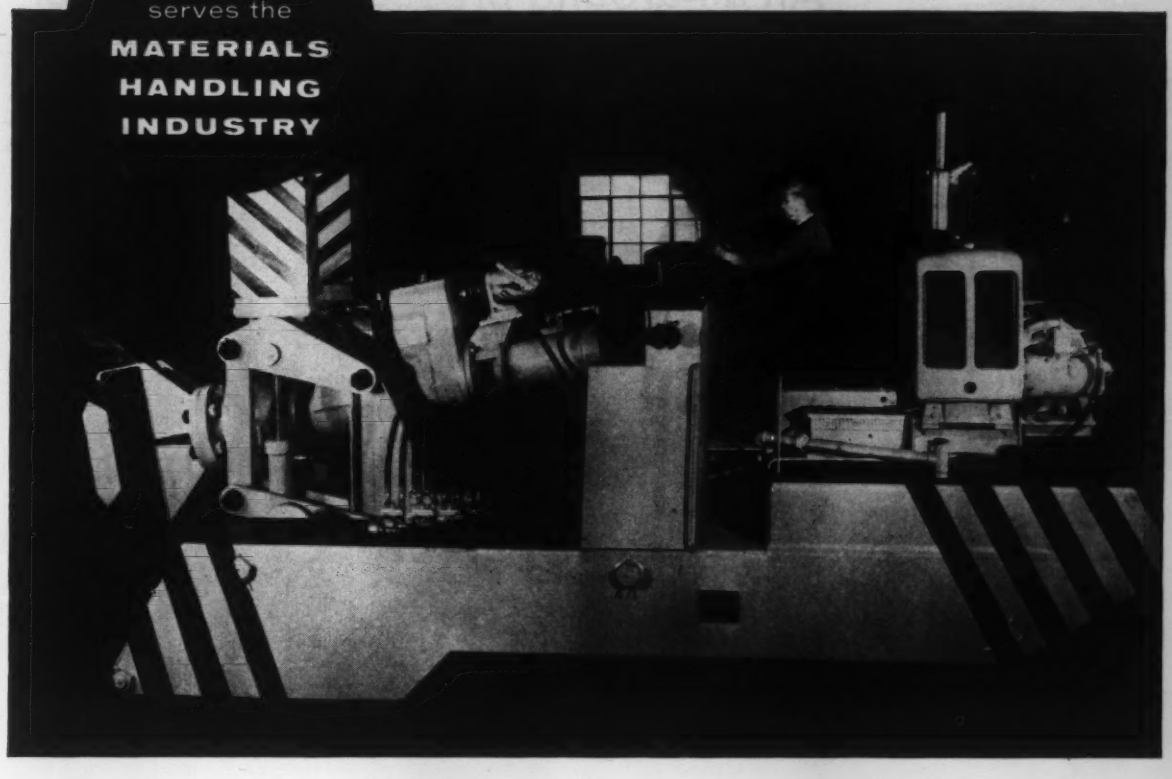
506 CHARLES AVENUE • MASSILLON, OHIO

SALES OFFICES: New York • Cleveland • Detroit • Chicago • St. Louis • San Francisco • Los Angeles

PRODUCTS: Engine Valves • Tappets • Hydraulic Valve Lifters • Valve Seat Inserts • Jet Engine Parts • Hydraulic Pumps Truck and Trailer Axles • Truck Transmissions • Permanent Mold Iron Castings • Automotive Heaters and Air Conditioners Fastening Devices • Cold Drawn Steel • Stampings • Forgings • Leaf and Coil Springs • Dynamatic Drives and Brakes Powdered Metal Parts • Gears • Variable Speed Drives • Speed Reducers • Differentials • Centralized Lubrication Systems

How **DENISON** serves the **MATERIALS HANDLING INDUSTRY**

HYDRAULIC-POWERED *manipulator built by Salem Brosius, Inc., Carnegie, Pennsylvania, uses Denison 5,000 psi axial piston pumps and motors and 2,000 psi vane-type motors to assure peak hydraulic-controlled efficiency.*



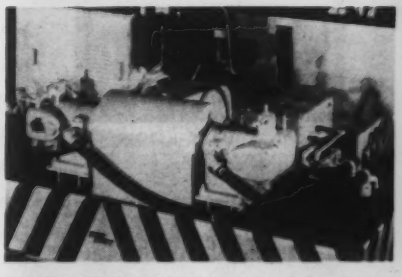
DENISON hydraulic-powered, this **SALEM BROSIUS**

Manipulator handles forgings 15% to 20% faster

Substantial savings in time and cost, through 15% to 20% faster handling of forgings, are accomplished with Salem Brosius' manipulator. Powered and controlled hydraulically with Denison pumps and motors, it has exceptional flexibility to perform the functions of charging machines, cranes, conveyor tables and roll chains, as well as the work of a manipulator.

Through the Denison hydraulic control, precise positioning of work in dies reduces rejects and off-quality work. Faster handling cuts reheats and fuel costs.

Whatever product you manufacture, it is likely that benefits through speed, added power and dependability can be incorporated at nominal cost. Ask your Denison representative to look over your requirements.



HYDRAULIC SYSTEM *for powering Salem Brosius forging manipulator. Powered by independent gasoline engine for in-plant mobility.*

DENISON ENGINEERING DIVISION
American Brake Shoe Co.
1240 Dublin Road • Columbus 16, Ohio
Denison Stocking Branch Offices: CHICAGO • DETROIT
LOS ANGELES • HOUSTON • ATLANTA • NEWARK • CLEVELAND

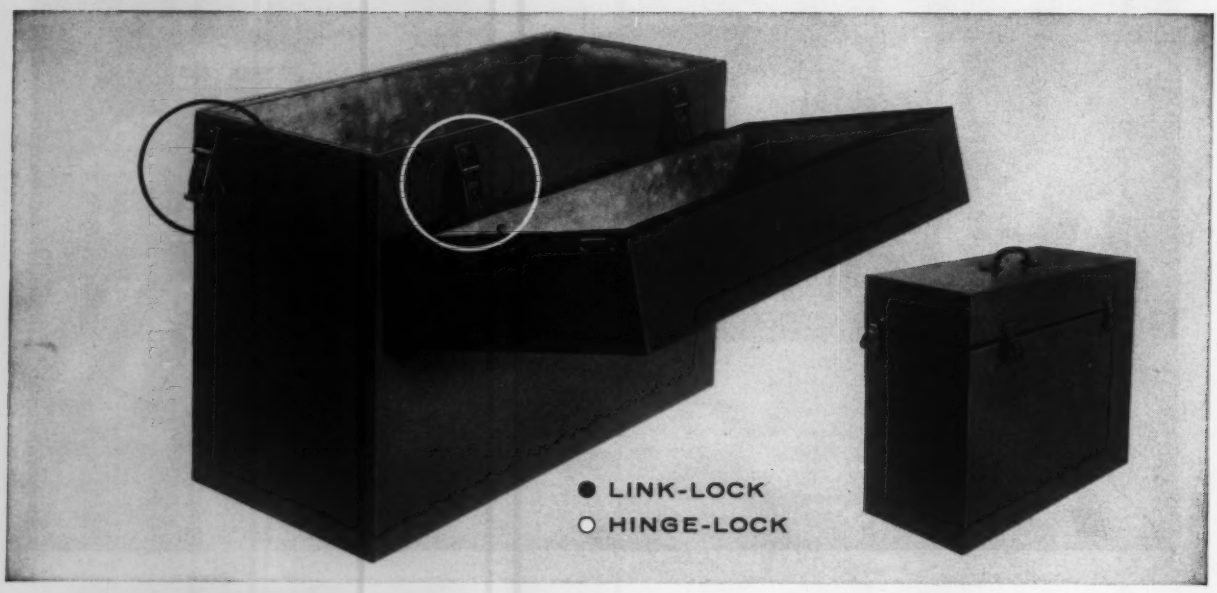
HYDRAULIC PRESSES • PUMPS • MOTORS • CONTROLS

Denison and Denison HydrOILics are registered trademarks of Denison Eng. Div., ABSCO

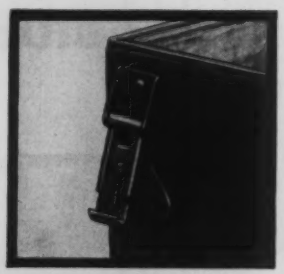
DENISON HydrOILics

Now

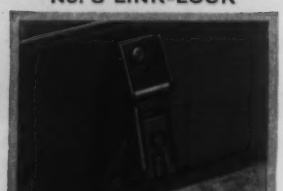
An all-around pressure-tight seal for hinged-cover transit cases with LINK-LOCK and HINGE-LOCK



Two HINGE-LOCK and two LINK-LOCK Fasteners provide all-around sealing pressure on this container manufactured for the U.S. Navy by the Bonded Structures Division, Swedlow Plastics Company.



No. 3 LINK-LOCK



No. 3 HINGE-LOCK

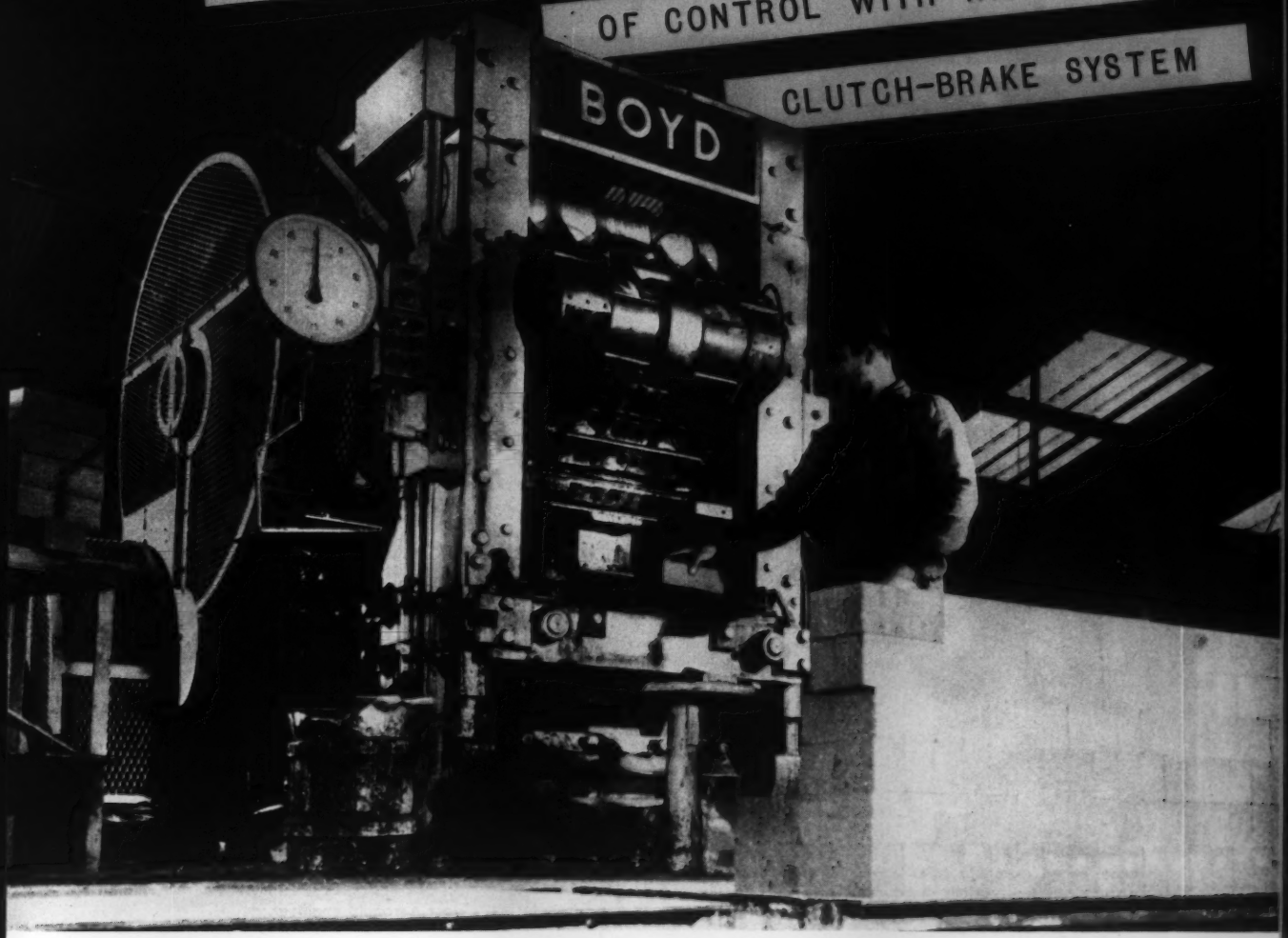
The new Simmons HINGE-LOCK, used in combination with LINK-LOCK, provides an even, pressure-tight seal on equipment containers and transit cases with hinged covers. A half-turn applies pressure to both types of fasteners. When pressure is released HINGE-LOCK becomes a free-operating hinge, and LINK-LOCK disengages to permit opening.

Originally developed by Simmons Fastener Corp. for the Engineering Department of Swedlow Plastics Company, Bonded Structures Division, HINGE-LOCK is similar in principle and appearance to LINK-LOCK. Both are available in light and medium duty sizes as matched hardware. LINK-LOCK is also available in a higher-capacity, heavy-duty size.

SEND TODAY for complete data, including dimensions, capacities. Engineering service is available... Outline your requirements. Samples on request.

SIMMONS *See our 8 page catalog in Sweet's Product Design File*
FASTENER CORPORATION 1756 North Broadway, Albany 1, New York
QUICK-LOCK • SPRING-LOCK • LINK-LOCK • HINGE-LOCK • ROTO-LOCK • DUAL-LOCK

BOYD PRESS INTRODUCES NEW FLEXIBILITY OF CONTROL WITH WICHITA CLUTCH-BRAKE SYSTEM



in addition . . . Boyd's Wichita System withstands rough treatment and cuts clutch-brake maintenance to practically nothing! Dan E. Koerner, Director of Research for Chisholm, Boyd, and White Company, Chicago manufacturers of refractory brick presses, says: "Wichita Clutch-Brake system is readily adapted to presses . . . withstands rough treatment . . . reduces customer complaints . . . introduces greater flexibility of control heretofore not possible . . . practically eliminates maintenance and is well engineered."

If you are interested in how these advantages of Wichita Clutching and Braking may be applied to your machines, contact your nearest Wichita Engineer . . . call or write today.

Contact your nearest Wichita Engineer!

Clutch & Control Engineering Co., Livonia, Mich.
L. H. Fremont, Cincinnati, Ohio
W. G. Kerr Company, Pittsburgh, Pa.
Smith-Keser & Co., Avon, Conn., Philadelphia 44, Pa., and New York, N. Y.
Frank W. Yarline Co., Chicago, Illinois
Larry W. McDowell, Long Beach, California
Andrew T. Lobel, Denver, Colorado
Robert R. King Co., Cleveland, Ohio
Norman Williams, Houston, Texas
Allied Transmission Equipment Co., Kansas City 8, Missouri
Donald E. Harman, Dallas, Texas
C. Arthur Weaver, Richmond, Virginia
Malcolm S. Cone, Memphis, Tennessee
Dominion Power Press Equipment, Ltd., Burlington, Ontario, Canada
R. E. Kunz, Seattle 4, Wash.
Norman Rupp Co., Portland 4, Ore.
Bates Sales Co., St. Louis 1, Mo.

WICHITA COMPANY, INC.

Circle 464 on Page 19

Aeroquip's Fluid Piping Service Solves

Experienced Aeroquip sales engineers work right in your plant assisting in the various production planning functions, making time-saving and money-saving recommendations.

Expediting and purchasing men get assistance from your Aeroquip representative in coordinating specifications and scheduling inflow of parts.

Instructing your personnel in proper installation on the assembly line is another service furnished by your Aeroquip engineer.

Production Problems for Manufacturers

WORKING RIGHT IN YOUR PLANT, AEROQUIP SPECIALISTS ASSIST IN ORDERING AND EXPEDITING, INSTALLATION AND ROUTING OF FLUID PIPING

The wide scope of Aeroquip's Fluid Piping Service can eliminate many problems for major equipment manufacturers.

At the production planning level, this unique service simplifies ordering and expediting. Aeroquip sales engineers recommend fluid line assembly, installation and routing techniques to your production engineers, also work right on the assembly line to assist in training your production personnel. And prompt deliveries are assured by Aeroquip's policy of forecasting industry requirements, plus multi-plant availability.

From design and prototype testing, through the important production stage, to field service and parts programming, highly qualified Aeroquip personnel work with you—in your plant or in the field. And, with this broad service concept, we accept full responsibility for performance of Aeroquip fluid piping.

You can obtain full information on this start-to-finish service by mailing the coupon below. Fill it in and mail it to us today!

Engineering assistance in finalizing production drawings can simplify installation techniques, prevent future service problems.

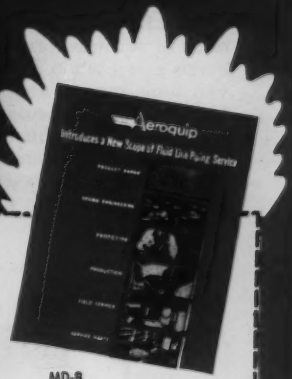
User satisfaction with the Aeroquip Fluid Piping on your equipment is guaranteed by Aeroquip field service available when needed.

- DESIGN
- PROTOTYPE
- PRODUCTION
- FIELD SERVICE
- SERVICE PARTS

Aeroquip

REG. TRADEMARK

AEROQUIP CORPORATION, JACKSON, MICHIGAN



Special Literature Available

Aeroquip Corporation, Jackson, Michigan

- ☐ Please send me a copy of Bulletin 614 explaining your complete service of fluid system design and performance.
- ☐ Please have an Aeroquip Sales Engineer call on me to discuss this service.

Name_____

Title_____

Company_____

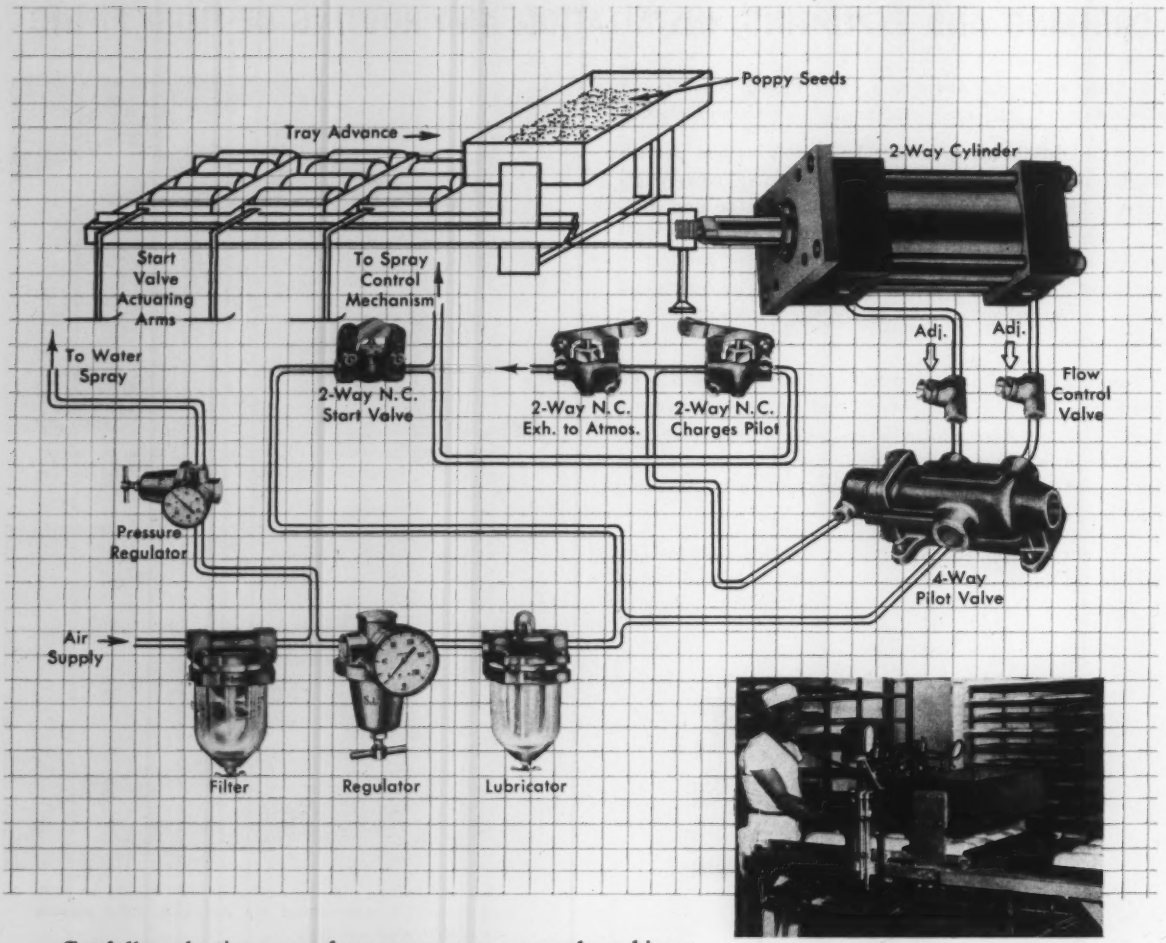
Address_____

City_____ Zone____ State_____

MD-8

Circle 465 on Page 19

PLANT MAKES STANDARD SCHRADER AIR PRODUCTS DO 65% OF THE WORK AUTOMATICALLY



Here's a typical example of how companies can automate with air. The hookup of Schrader Air Products in the large picture was used to perform repetitive operations by General Baking Company, Detroit, Michigan. A tray of loaves moving on a belt trips a Schrader 2-way valve which actuates the water spray mechanism—and starts the 4-way valve-operated reciprocating system. The 4-way valve operates the cylinder which sifts poppy seeds onto each loaf in turn. This was formerly repetitive hand work. Schrader representatives helped plan this effective air system, as they have helped plan innumerable others.

Get full productive power from your manpower and machines, like this company. Simply take advantage of the *air* you already have! Hook up Schrader Air Products to fit your needs and get these benefits:

AIR IS FAST AND ACCURATE: time operations to fractions of seconds, produce at high speed. **AIR IS TIRELESS:** keeps going when fingers fail. **AIR IS ECONOMICAL:** saves you time, money and effort. **AIR IS SAFE:** reduces operator fatigue and machine-fear.

These are benefits every shop needs. Get them all when you automate with Schrader . . . the finest line of Air Cylinders, Valves and Accessories . . . and ideas for cutting your operating costs.

Use the full Schrader line to do your air control selecting. Your Schrader distributor can help you pinpoint what you need. For more data write:

A. SCHRADER'S SON
Division of Scovill Manufacturing Company, Incorporated
476 Vanderbilt Avenue, Brooklyn 38, N. Y.

Schrader®
a division of SCOVILL

QUALITY AIR CONTROL PRODUCTS

Announcement of Major Significance

FOR EVERY USER OF SOCKET HEAD CAP SCREWS

Following exhaustive studies begun in 1954, the socket screw products industry adopted, on April 24, 1959, new dimensional standards for socket head cap screws. Standard Screw Company participated in these studies and concurred in the recommendations approved by leading fastener manufacturers.

Adoption of the new standards, to be known as the "1960 Series", has important implications for every user of socket screws. As a public service Stanscrew will point out these implications . . . not only in relation to its own products, but also to the overall program of the industry.

Differences, Advantages Of New Design

The "1960 Series" has been carefully engineered so there is functional uniformity for all sizes, particularly as it applies to wrenching areas and to the relationship of head diameters to body diameters. For most sizes, as illustrated, this means substantial increases in both head diameter and socket size, and thus provides these advantages over the present design:

1. *Maximum utilization of the fastener's inherent strength . . . larger wrenching area permits application of greater clamping force.*
2. *Increased bearing surface under the head . . . up to 233% more.*
3. *Minimum indentation . . . particularly important with softer metals.*

Should You Convert Now?

Obviously, for many applications, the new design offers important benefits which indicate conversion as rapidly as possible. In some cases, however, existing product design may not accommodate the larger heads . . . or, where socket cap screws are countersunk, revising your countersinking operations may create significant production problems. Stanscrew urges, therefore, that each company learn complete facts on the fastener industry's future plans.

Timetable For Industry Changeover

Stanscrew has already started production of the new "1960 Series". Manufacture of the present (1936) series will continue, however, and they will be available as standard, in-stock items until at least January 1, 1961. At that time, it is now contemplated the "1960 Series" will become the accepted standard throughout industry and the "1936 Series" will then be furnished only when specifically ordered.

When Designing A New Model

For products now on the drawing board, this timetable indicates many manufacturers should plan to use the "1960 Series" as the standard for later production. By making such design provisions, you assure maximum acceptance and minimum difficulty in the future.

For Existing Products

For many existing applications, where socket cap screws are not countersunk, either the 1936 or the "1960 Series" may be used. In frequent cases, improvements of the 1960 design suggest conversion within a short period. In other applications, where the heads are countersunk or where the greater head diameters of the "1960 Series" create a problem, changeover should probably be postponed until a general redesign of your product is scheduled.

Special Stanscrew Marking

To further distinguish its "1960 Series", Stanscrew will knurl heads of all new style socket cap screws with a split herringbone design (as shown). This special marking and the new "1960 Series" box labeling will provide quick identification of these quality fasteners.

For Further Information

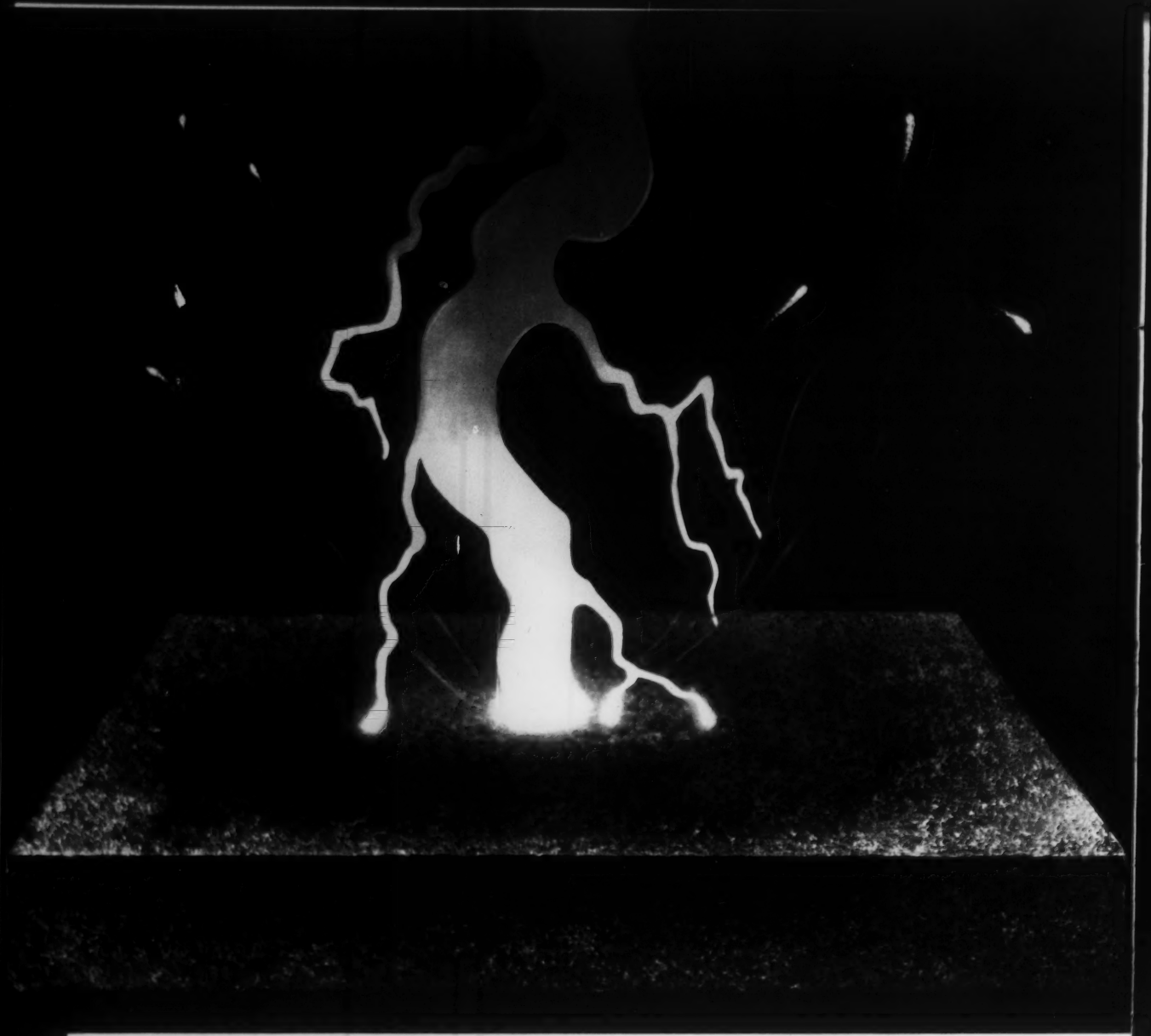
Your Stanscrew distributor has the latest facts on the new "1960 Series" and will be happy to discuss them with you. If desired, he also will arrange for a prompt visit from a Stanscrew fastener specialist who will be most happy to go over all aspects of this new industry program as it regards your own particular operation.

Stanscrew also has a new brochure which provides complete dimensional and design data on the "1960 Series". No obligation, of course, for your copy.

STANSCREW FASTENERS

CHICAGO | THE CHICAGO SCREW COMPANY, BELLWOOD, ILLINOIS
HMS | HARTFORD MACHINE SCREW COMPANY, HARTFORD, CONNECTICUT
WESTERN | THE WESTERN AUTOMATIC MACHINE SCREW COMPANY, ELYRIA, OHIO

STANDARD SCREW COMPANY 2701 Washington Boulevard, Bellwood, Illinois



High voltage "lightning" discharge at a Malleable test block.

Toughness is Malleable

Under the slamming, bruising strain of a bulldozer's roughshod ride . . . inside the battering air hammer . . . against the repetitive concussion of a machine gun's smashing action . . . wherever conditions are really brutal, Malleable iron castings prove their ruggedness.

When you're looking for toughness, it will pay you to investigate Malleable castings. Contact one of the progressive firms that displays this symbol—

If you wish, you may inquire direct to the Malleable Castings Council, Union Commerce Building, Cleveland 14, Ohio, for information.

MEMBER
MALLEABLE
CASTINGS COUNCIL

New Malleable Irons Meet Gruelling Service Tests

Toughness is a vital requirement in stressed parts. Each application, however, requires a particular combination of physical characteristics to be sufficiently "tough."

Whatever the specific requirements, one of the finest groups of materials available is the Malleable irons, as illustrated in the tables below.

Tensile Properties—A.S.T.M. Minimum Specifications
Standard and Pearlitic Malleable Irons

Designation	Tensile Strength p.s.i.	Yield Strength p.s.i.	Elongation % in 2 in.	Designation	Tensile Strength p.s.i.	Yield Strength p.s.i.	Elongation % in 2 in.
Standard				53004	80,000	53,000	4
35018	53,000	35,000	18	60003	80,000	60,000	3
32510	50,000	32,500	10	80002	100,000	80,000	2
Pearlitic							
45010	65,000	45,000	10				
45007	68,000	45,000	7				
48004	70,000	48,000	4				
50007	75,000	50,000	7				

Strengths up to 135,000 p.s.i. tensile and 110,000 p.s.i. yield are produced commercially under individual producers' specifications.

Other Mechanical Properties
Standard and Pearlitic Malleable Irons

	Standard	*Pearlitic*
Modulus of Elasticity in Tension, p.s.i.	25,000,000	26,000,000—28,000,000
Ration of Fatigue Strength to Tensile Strength	0.54	0.40—0.50
Shear Strength—% of Tensile Strength	80—90%	70—85%
Torsional Strength	Approximately equal to Tensile Strength	
Compressive Strength, p.s.i.	200,000	250,000

Malleable's toughness is illustrated in a severe test conducted by a manufacturer of cab-over-engine trucks. To be absolutely sure of the strength and toughness of a variety of components in the cab, including the critical Malleable iron cab support hinges, a truck was crashed at high speed into a barricade of ice. Result—no hinge damage, even though the truck was seriously battered.

Service-Demonstrated Toughness

Highway railing posts demonstrate Malleable castings' use where impact resistance is critical. As an example, thousands of Malleable railing posts line the Connecticut State Thruway. The State Highway Department reports that there have been no failures of the Malleable iron posts although other materials have failed in several cases.

It is also because of Malleable's toughness that so many of the highest quality hand tools are made of Malleable iron. One leading tool manufacturer tests the quality of its pipe wrenches by using a trick well known as the best way to break a wrench. The wrench jaws are put on a rigid bar, a long pipe is slipped on the handle, and the tester heaves his weight downward on the pipe. Because of their confidence in Malleable's toughness, this company unconditionally guarantees every Malleable wrench housing against distortion and breakage. Another hardware manufacturer makes a similar guarantee against breakage on its line of Malleable vises.

But Malleable iron's proven performance in field service is only one reason for its wide use. To this, you must add Malleable's low first cost, design flexibility, and excellent machinability. This combination offers unique advantages over other metals.

Design and Production Assistance Available

To assist in the use of Malleable castings, a special bulletin on toughness—Data Unit No. 105—is available from the Malleable Castings Council, Union Commerce Building, Cleveland 14, O. These bulletins and engineering and planning assistance are also readily available to you from any member of the Malleable Castings Council.

These companies are members of the

MALLEABLE CASTINGS COUNCIL

CONNECTICUT
Connecticut Mall. Castings Co., New Haven 6
Eastern Malleable Iron Co., Naugatuck
New Haven Malleable Iron Co., New Haven 4

DELAWARE
Eastern Malleable Iron Co., Wilmington 99

ILLINOIS
Central Fdry. Div., Gen. Motors, Danville
Chicago Malleable Castings Co., Chicago 43
Moline Malleable Iron Co., St. Charles
National Mall. and Steel Castings Co., Cicero 50
Peoria Malleable Castings Co., Peoria 1
Wagner Castings Company, Decatur

INDIANA
Link-Belt Company, Indianapolis 6
Muncie Malleable Foundry Co., Muncie
Terre Haute Mall. & Mfg. Corp., Terre Haute

MASSACHUSETTS
Belcher Malleable Iron Co., Easton

MICHIGAN
Albion Malleable Iron Co., Albion
Auto Specialties Mfg. Co., Saint Joseph
Cadillac Malleable Iron Co., Cadillac
Central Fdry. Div., Gen. Motors, Saginaw

MINNESOTA
Northern Malleable Iron Co., St. Paul 6

NEW HAMPSHIRE
Laconia Malleable Iron Co., Laconia

NEW JERSEY
Meeker Foundry Company, Newark 4

NEW YORK
Acme Steel & Mall. Iron Works, Buffalo 7
Frazer & Jones Company Division Eastern Malleable Iron Co., Solvay
Oriskany Malleable Iron Co., Inc., Oriskany
Westmoreland Mall. Iron Co., Westmoreland

OHIO
American Malleable Castings Co., Marion
Canton Malleable Iron Co., Canton 5
Central Fdry. Div., Gen. Motors, Defiance
Dayton Mall. Iron Co., Ironton Div., Ironton
Dayton Mall. Iron Co., Ohio Mall. Div., Columbus 16
Maumee Malleable Castings Co., Toledo 5
National Mall. and Steel Castings Co., Cleveland 6

PENNSYLVANIA
Buck Iron Company, Inc., Philadelphia 22
Erie Malleable Iron Co., Erie
Lancaster Malleable Castings Co., Lancaster
Lehigh Foundries Company, Easton
Meadville Malleable Iron Co., Meadville
Pennsylvania Malleable Iron Corp., Lancaster

TEXAS
Texas Foundries, Inc., Lufkin

WEST VIRGINIA
West Virginia Mall. Iron Co., Point Pleasant

WISCONSIN
Belle City Malleable Iron Co., Racine
Chain Belt Company, Milwaukee 1
Federal Malleable Company, West Allis 14
Kirsh Foundry Inc., Beaver Dam
Lakeside Malleable Castings Co., Racine
Milwaukee Malleable & Grey Iron Works, Milwaukee 46

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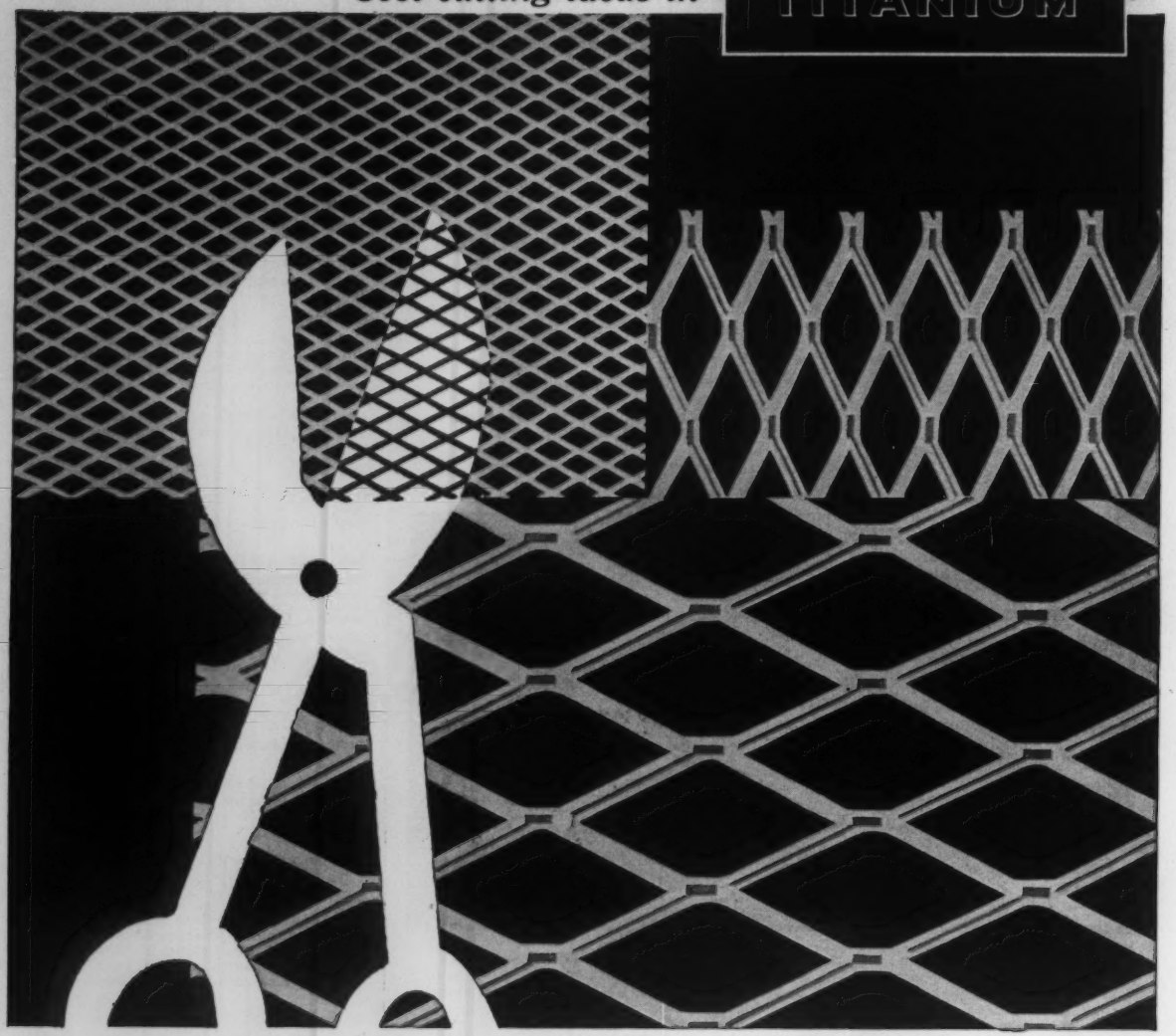
Cost cutting ideas in **TITANIUM**



Visit our Booth No. 1151 at Western Metal Exposition, March 16-20, Pan-Pacific Auditorium, Los Angeles.

EXPANDED TITANIUM SHEET

"opens up" new savings in corrosive plating applications

Now, cost-saving applications for titanium take another important step forward. Expanded titanium sheet, recently introduced by Mallory-Sharon, offers interesting possibilities for use in the plating and chemical processing industries.

Dip baskets

Filters

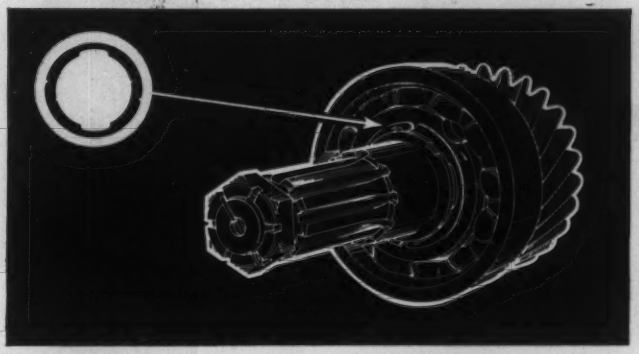
Its high corrosion resistance makes it ideal for use in acid plating, acid dipping baskets, and in protection shields for immersion heating electrodes. The new material is available in gauges from .015" to .125", from ⅛" to 1½" diamonds, and in standard 48" x 96" sheets.

Protective shields

Expanded titanium sheet is now available in production quantities. Prices vary with gauge and strand widths. For further information, write for Technical Data Sheet.

MALLORY SHARON

MALLORY-SHARON METALS CORPORATION • NILES, OHIO



Heavy duty transmission design simplified. On this dual axle drive for trucks, a Truarc Series 5107 ring locks bearing on drive shaft. Interlocking ring design won't dislodge under heavy torque . . . is also recommended for high rpm. applications.

Designing with radially assembled Waldes Truarc retaining rings

solve varied product design problems—save machining, materials, parts and labor

Radially assembled retaining rings, which snap onto a shaft at right angles to its axis, greatly extend the range of products on which retaining rings may be used to simplify design and save parts or labor costs.

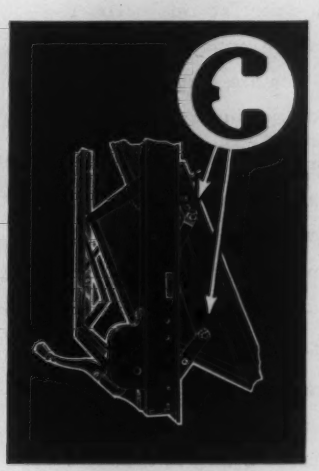
For example, rings for radial assembly can be used in applications where it is impossible to install a ring axially over the end of a shaft. Certain types are designed to accommodate shafts of relatively wide tolerances. Others described below may be used to provide a sizeable shoulder on a shaft.

The four applications shown here provide an indication of the wide range of products using radially assembled rings. The rings themselves are basic Truarc types each having specific design features. The high shoulder of one provides a large bearing surface on small diameter shafts; the low shoulder of another is ideal where clearance is limited. A third has an interlocking design which prevents it from being dislodged under torque or high rpm. A fourth can be used against rotating parts at the same time it provides spring tension.

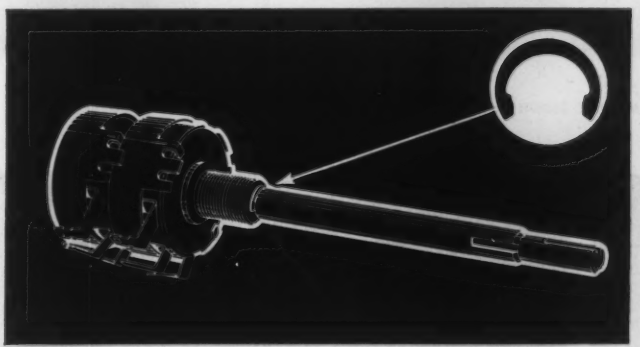
These are but four of Truarc's fifty functionally different types of retaining rings with up to 97 sizes within a single type, six metal specifications and thirteen different finishes. Special hand, magazine, and semi-automatic applicators as well as grooving tools are also available to speed production. The entire line, together with over 70 typical applications, is described and illustrated in the new catalog RR10-58—yours for the asking. And call on us for design assistance on your specific project . . . a Waldes Truarc engineer will be glad to help. Waldes Kohinoor, Inc., 47-16 Austel Place, Long Island City 1, N. Y.

©1959 WALDES KOHINOOR, INC. 9.9

Rings replace machined shoulders, collars, set screws. That's what original design of this pneumatic temperature transmitter called for. Series 5139 Prong-Lock® ring with bowed design compensates for accumulated tolerances in parts, provides sufficient friction to prevent rotation under vibration. At the same time two Waldes E-rings position and lock adjustment screw to face plate.



Reinforced aluminum ring gives design advantages on louver windows. Waldes Truarc Series 5144 reinforced rings of aluminum secure hinge pins, eliminate costly riveting in linkage of louver type window. Ring design provides large bearing shoulder. Reinforced construction has 5 times the gripping strength of standard E-ring construction, allows use of non-corrosive aluminum.



Ring acts as locking shoulder. Holding the threaded ferrule on this potentiometer shaft is a Truarc Series 5103 Crescent® ring. Crescent ring design with low shoulder provides ample clearance for assembly of panel locknut. It is less costly than a machined shoulder, more effective, quicker to install, easier to remove than the C washer previously used.

WALDES TRUARC® RETAINING RINGS

Waldes Kohinoor Inc., Long Island City 1, N. Y.

TRUARC RETAINING RINGS...THE ENGINEERED FASTENING METHOD FOR REDUCING MATERIAL, MACHINING AND ASSEMBLY COSTS

How to hang 40 tons of beer from the ceiling

These vessels, called "Dual-Paraboloid" fermentation tanks, are shaped like giant toasters. They're 21 feet long, 13 feet high, and 12½ feet at the widest point. Solar Chicago, Division of U.S. Industries, Inc., makes them from 13-gage Type 304 Stainless Steel sheets that are curved and welded together to form a cornerless interior. 1″ x 4″ ribs are welded around the outside of the tank and all welds are ground to a uniform finish.

Each of the tanks will hold 450 barrels, more than 40 tons, yet the tanks themselves are so light that the entire load will be hung from the ceilings of modern breweries. The formability, weldability and strength of Stainless Steel permitted this unique design. Because the Stainless is so strong, they could use thinner, *lighter* walls.

These tanks weigh 5 tons and they will replace old, square-cornered ones that weighed about *20* tons. Breweries are happy . . . the cornerless, Stainless tanks are easier to keep clean, and because they're off the floor, the plant itself stays cleaner. And because they're Stainless Steel, they will probably never have to be replaced.

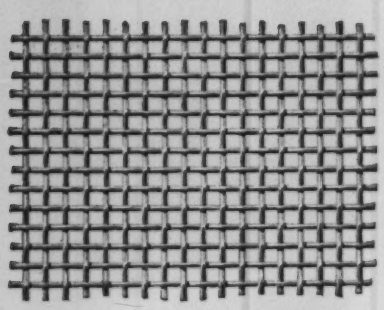
USS is a registered trademark

United States Steel Corporation—Pittsburgh
American Steel & Wire—Cleveland
National Tube—Pittsburgh
Columbia-Geneva Steel—San Francisco
Tennessee Coal & Iron—Fairfield, Alabama
United States Steel Supply—Steel Service Centers
United States Steel Export Company

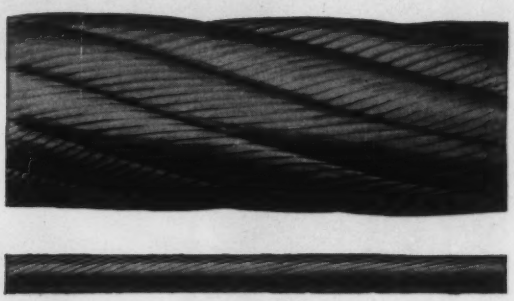
United States Steel

Please direct inquiries to advertiser, mentioning MACHINE DESIGN

whatever you make in stainless steel wire

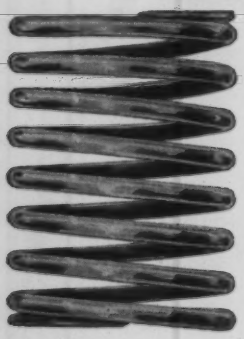


mesh

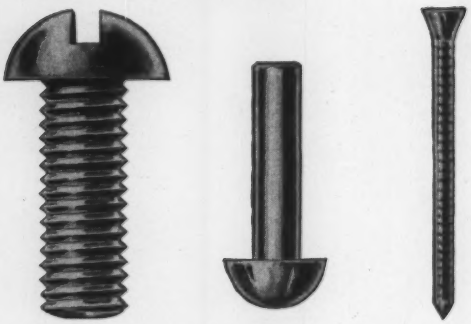


rope

springs



cold-headings



let Allegheny quality help cut production costs

You start off with cold-drawn wire of almost every standard grade, tempered to provide many correlations of hardness and tensile strength to fit a wide variety of stainless steel wire products.

You go from there to Allegheny quality—absolute uniformity in every order. Your specifications are faithfully followed, order after order, and that adds up to savings in production costs.

If you make springs, you get uniform tensile strength in every batch . . . and with rope wire.

In weaving wire you get the same deadsoft temper, uniform properties for perfect weaving without ridges.

In cold-headed wire you get absolute uniformity that ties in with automation production processes.

Whatever you make in stainless wire, Allegheny Ludlum offers you adequate stocks of all standard grades for fast shipment. Special stainless steel wire on order.

A-L's technical staff will be glad to help you with problems of selection and fabrication, or offer technical assistance to help you cut shop costs.

Allegheny Ludlum Steel Corporation, Oliver Building, Pittsburgh 22, Pa. Address Dept. MD-20.

Write for your copy of Allegheny Stainless Wire, Illustrated 20-page booklet, which fully describes analyses, physical properties, corrosion resistance and principal applications of stainless wire.

7580

AL

ALLEGHENY LUDLUM

for warehouse delivery of Allegheny Stainless, call RYERSON

Export distribution: AIRCO INTERNATIONAL

EVERY FORM OF STAINLESS . . . EVERY HELP IN USING IT

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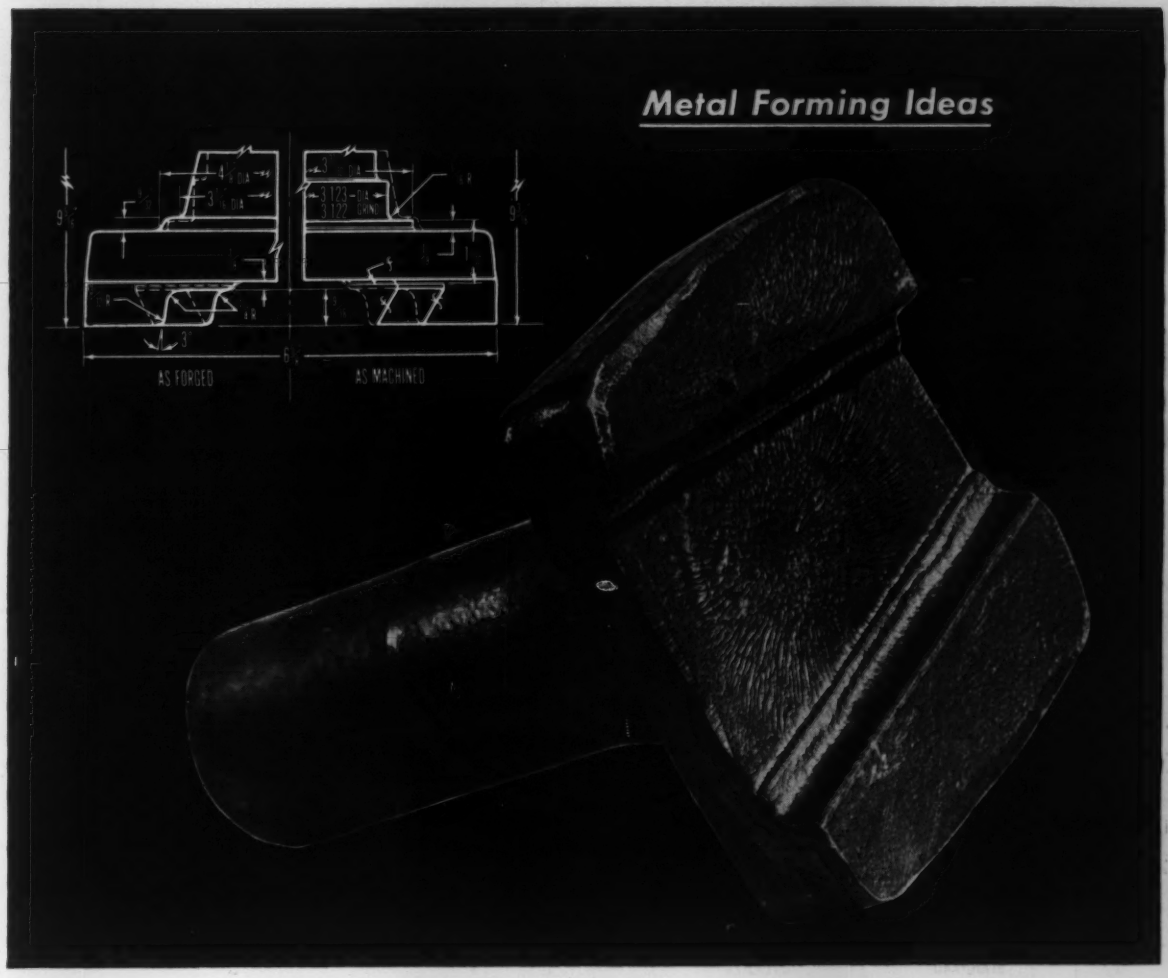
Metal Forming Ideas

How upsetting saves metal—reduces machining

Key part in a new multi-purpose farm tractor by Minneapolis-Moline was a steering link pedestal which involved unusual requirements both as to its final performance and actual production.

On the performance side, the design of forged pedestal gives Minneapolis-Moline customers a three-in-one tractor. In a matter of minutes change-over of three different front ends is made through the dovetailed groove.

From the production standpoint, the part was unusual in both shape and design—included a dovetailed groove in its head, plus an off-center shaft.

The requirement: A metal and a forming method which could produce this unusually shaped key component to meet all requisites on strength, lightweight, and yet afford maximum savings on both metal and machining of the forging.

The "Task-Forging" team at COMMERCIAL, working closely with Minneapolis-Moline engineers, proved that upset forging, despite the fact that it is rarely considered for the forming of off-center shaft components—particularly when they also involve a dovetail groove swaged in one end like this one—could best meet this requirement on every count. The steering link is now being successfully produced as an upset forging on a 6" upsetter by COMMERCIAL.

As an upset forging it is more than strong enough to do the job. The controlled grain flow and efficient metal distribution afforded by upset forging assures maximum tensile and torsional strength. Equally important, there are no hidden, inside faults in the finished part—sound, dense, non-porous, forged metal from center-to-surface eliminates rejects, makes machining more effective.

At a finished weight of 22½ lbs. (after machining) the steering link is easily light enough. And since the weight of the upset forging (before machining) was 27 lbs., the important savings in both metal and machining made possible by the inherent close tolerances of the upset forgings produced by COMMERCIAL are obvious.

Whether you're looking for help in the forming of a new component or only considering an improvement in the forming of an already existing part, "Task-Forging," COMMERCIAL'S new metal forming service—backed by over 30 years of metal forming experience, plus specialized equipment which includes 1½" thru 8" upsetters—may be able to help you. Address inquiries to Commercial Shearing & Stamping Company, Dept. S-34, Youngstown 1, Ohio.

COMMERCIAL
shearing & stamping

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SPS RELIABILITY / *A dynamic standard of predictable performance*

Precision of UNBRAKO Dowel Pins cuts cost in many applications

Precise tolerances of ±0.0001 inch and consistently uniform physical characteristics, maintained by automatic gaging, and atmosphere-controlled heat treatment, make UNBRAKO Dowel Pins reliable cost-cutters in many different applications.

These precision products are so accurate that many plants use them as plug gages in numerous production operations. Others use them as guide pins, stops, wrist pins, hinges and shafts; as position locators on indexing machines; as feeler gages in assembly work; as valves and valve plungers on hydraulic equipment; as fasteners for laminated sections and machine parts; as roller bearings in casters and truck wheels.

Your authorized SPS distributor stocks UNBRAKO Dowel Pins in two types: Blue Label Pins .0002 inch oversize to meet nominal press fit requirements; and Red Label Pins .001 inch oversize for use as repair pins.

See your nearest distributor for complete details. Or write SPS—manufacturer of precision threaded industrial fasteners and allied products in many metals, including titanium.

◀ Typical of the many applications of UNBRAKO Dowel Pins is this die. Here the pins are used to position laminated sections.

Nominal Diam.	STANDARD (.0002 inch over diameter listed)		OVERSIZE (.001 inch over diameter listed)		Point Diam.	Top Radius	Bottom Radius
	Max.	Min.	Max.	Min.			
1/16	0.0646	0.0642	0.0636	0.0634	0.0054	0.015	0.005
1/8	0.1253	0.1251	0.1261	0.1259	0.116	3/64	1/64
3/16	0.1878	0.1876	0.1886	0.1884	0.178	3/64	1/64
1/4	0.2503	0.2501	0.2511	0.2509	0.237	1/16	1/64
5/16	0.3128	0.3126	0.3136	0.3134	0.298	1/16	1/64
3/8	0.3753	0.3751	0.3761	0.3759	0.359	5/64	1/64
7/16	0.4378	0.4376	0.4386	0.4384	0.417	3/32	1/32
1/2	0.5003	0.5001	0.5011	0.5009	0.480	7/64	1/32
5/8	0.6253	0.6251	0.6261	0.6259	0.605	1/8	1/32
3/4	0.7503	0.7501	0.7511	0.7509	0.725	1/8	1/32
7/8	0.8753	0.8751	0.8761	0.8759	0.850	1/8	1/32
1	1.0003	1.0001	1.0011	1.0009	0.975	1/8	1/32

OTHER CHARACTERISTICS OF UNBRAKO DOWEL PINS

- **Surface Hardness:** Rockwell C Scale: 60-62
- **Surface Finish:** 6 microinch maximum
- **Core Hardness:** Rockwell C Scale: 50-54
- **Case Depth:** .020 inch minimum
- **Average Shear Strength:** 150,000 psi
- **Diameter Tolerance:** ±0.0001 inch

INDUSTRIAL FASTENER Division SPS

JENKINTOWN 18, PENNSYLVANIA

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A big feature for tomorrow's best selling cars!

TIRES OF BUTYL

Over the years versatile Enjay Butyl rubber has proven its superior performance in tubes, weatherstrips, radiator hose, shock absorbers and countless other automotive applications.

Imagine the outstanding selling opportunity of new cars equipped with Butyl tires. One short demonstration ride can prove all these unique features. Butyl tires *hug the road so well you can't make them squeal,* at any corner, at any speed, at any stop. So effective is their traction *they stop up to 30% quicker* than ordinary tires — even stop faster on wet surfaces than other tires do on dry. And because *Butyl absorbs shock energy better,* tires of Butyl *flow* over bumps, minimize shock, vibration, and noise.

Now the wide range of Butyl compounds gives new freedom to tire designers and product designers in every industry. Let us show you how Butyl can help you make better products.

For complete information—*Write or phone your nearest Enjay office. Enjay's extensive laboratories and expert staff are always glad to provide technical assistance on request.*

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EXCITING NEW PRODUCTS THROUGH PETRO-CHEMISTRY

ENJAY COMPANY, INC., *15 West 51st Street, New York 19, N.Y.*

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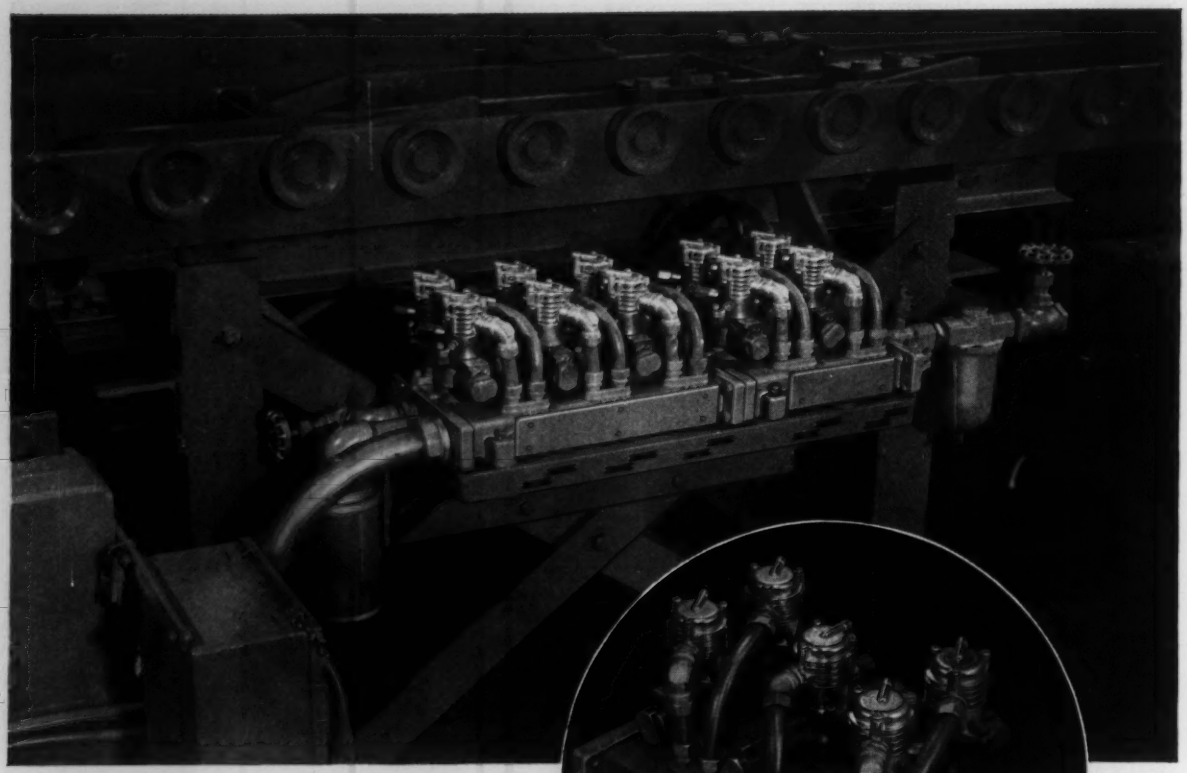


This bank of manifold-mounted Speed King valves controls a foundry mold flask indexing unit, custom-built for a major automotive manufacturer.

to simplify piping and wiring of complex control valve installations, use...

VALVAIR'S NEW SPEED KING® MANIFOLDS

Cut material and assembly labor costs on multiple control valve installations . . . use Valvair's new 2 and 3-station manifolds! Common inlet, exhaust and wiring passages, plus equally-spaced cylinder ports, eliminate unnecessary piping and wiring . . . keep installations neat. Cast aluminum manifolds may be ganged for installation of any number of valves. O-rings assure leak-free connections.

VALVES — 2 or 3 stations for 3/8-3/4 in. NPT standard Speed King or 1/4 in. NPT plug-in Speed King Valves, single or double solenoid, 2, 3 or 4-way. Remote operated, speed controlled* and power-centered neutral* valves may be used in any number and combination.

PIPING — Intake and exhaust ports common to all stations. Pipe threads, both ends, and O-ring grooves.

PORTING — Optional size cylinder ports. Side and bottom outlets, flush pipe plugs.

WIRING — Large conduit passage, with side access cover, common to all stations. Pipe threads, both ends, and O-ring grooves. Pilot leads (standard Speed King valves) encased in flexible conduit, integral pilot connections for 1/4 in. NPT plug-in Speed Kings.

MOUNTING — 2 mounting points per manifold. For ganging, kits of O-rings and through bolts are offered.

**Standard Speed King valves only.*

Easier in-use service is another benefit! Individual pilots, valves or entire manifolds are replaceable as units to minimize machine downtime.

And, Speed King manifolds *are available for immediate delivery from stock.* Before you engineer new equipment or up-grade machines now in service, investigate the design and cost advantages of Valvair Speed King manifolds.

For more information, write for Bulletin D-58. Address Dept. MD859, Valvair Corporation, 454 Morgan Ave., Akron 11, Ohio.

Representatives in principal cities.

Valvair AKRON 11, OHIO

Other INDUSTRIAL DIVISIONS of IBEC The Sinclair-Collins Valve Co. The Bellows Co., Akron, Ohio • V D Anderson Co., Cleveland, Ohio.

8005

PHOTO BY KARSH OF OTTAWA

"Materials are important to the designer. . . thats why Talon, Inc. works with Sharon"

—THANE E. HAWKINS, chief engineer, Shu-Lok Fastener Division, Talon, Inc.

"To design properly the engineer has to know materials—their advantages and limitations," states Thane E. Hawkins, chief engineer, Shu-Lok Fastener Division of Talon, Inc.

"The Shu-Lok, we knew, would have to absorb extra heavy punishment—yet be as inconspicuous as possible. This meant a small, tough precision product. These factors dictated the use of steel—stainless steel. To get the quality stainless we needed, it was only natural to look to *Sharon Steel Corporation, Sharon, Pa.*"

SHARONSTEEL **SHARON** *Quality* **STEEL**

Circle 476 on Page 19

STEEL LINES FOLD LIKE AN ACCORDION

Typical of diverse swivel joint applications, newly designed Chiksan Discpak joints are installed on the steam lines of a platen press. This new type swivel joint, designed for hot gas and steam, allows inexpensive packing replacement without removing swivel joint from line.

WHEN *design* DICTATES METAL LINES . . .

SOLVE LINE FLEXING PROBLEMS

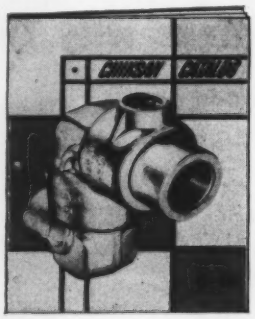
with **CHIKSAN SWIVEL**

Chiksan swivel joints allow metal lines to be flexed in predetermined travel arcs, eliminate hose rupture, reduce maintenance and replacement costs.

Where tight bends in pressure hose make wide loops necessary, Chiksan swivel joints, conversely, permit compact placement of lines. When used with hose, Chiksan swivel joints shorten hose lengths and also lengthen hose life by minimizing tight bend and torsional fatigue.

Chiksan swivel joints are available from stock in a wide range of materials, temperatures, and pressures to meet practically every design requirement. Chiksan swivel joint packing units are designed for specific services. For example, packings have been developed to efficiently handle non-inflammable hydraulic fluids. Write today for catalog and name of nearby sales engineer.

LONG SERVICE LIFE ➤ Chiksan swivel joints deliver years of service with only occasional maintenance attention. All-steel hydraulic lines on Flash-Butt welder, shown at right, allow lines to shift as machine is adjusted to handle various work.



A SUBSIDIARY OF FOOD MACHINERY AND CHEMICAL CORPORATION

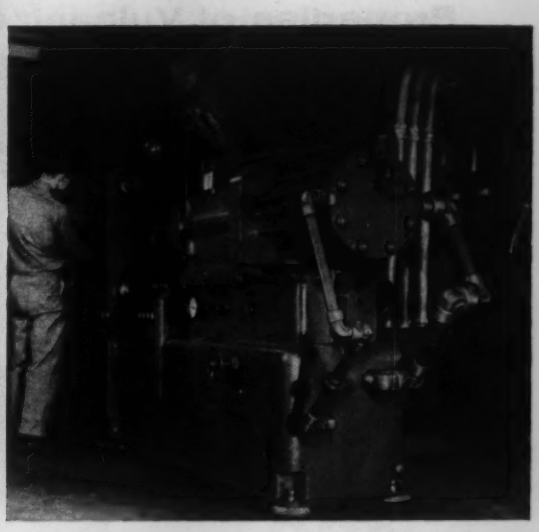
fmc **CHIKSAN**

CHIKSAN COMPANY—BREA, CALIFORNIA • CHICAGO 5, ILLINOIS • NEWARK 2, NEW JERSEY

Well Equipment Mfg. Corp. (Division), Houston 1, Texas • Subsidiaries Chiksan Export Company • Chiksan of Canada Ltd

NO HOSE BURST DANGER HERE...

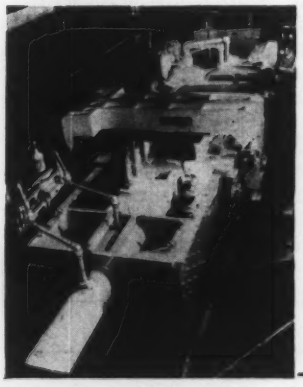
Critical lines take on a new measure of safety with all-steel flexible units replacing pressure hose. These all-metal swivel jointed lines shown on a die casting machine above, eliminate damaging hose ruptures, and reduce fire hazard, fluid loss and setup time by 75%.



PRESSURE? TEMPERATURE? CHIKSAN MEETS THE NEED...

Over 2,000 different types, styles and sizes in a variety of temperature and pressure ratings are available to meet your design needs. This plastic injection molding machine, above, uses two different sizes of Chiksan swivel joints on its hydraulic lines.

JOINTS



NO LIMIT ON LINE DESIGN

Free swiveling action in 1, 2 and 3 planes permits design of compact lines to meet any requirement. This overhead line in service at a water softener regenerating plant permits shift from one setup of tanks to another for faster handling of tank regeneration.

#58-31

CHIKSAN COMPANY
330 NORTH POMONA AVENUE, BREA, CALIFORNIA

Please send me copy of your latest catalog

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Title_____ Address_____

City_____ Zone_____ State_____

Spaulding FIBRE FACTS FOR ENGINEERS NUMBER 1

The Unique Deionizing and Non-Arc Tracking Properties of Vulcanized Fibre and Their Applications

by Earl A. Russell, Chief Engineer, Spaulding Fibre Company, Inc.

• When subjected to high temperatures such as those created by an electric arc, Spaulding Vulcanized Fibre produces an arc-quenching gas. Two important effects are noted:

1. The Fibre neutralizes the charges present in the air that has been ionized by the arc, permitting instant reassociation or deionizing. Ionized air conducts electricity. Deionizing it re-establishes air's normal insulating characteristics, thus extinguishing the arc and preventing the line current from flowing through to ground.

2. The Fibre covers itself with a gaseous, nonflammable layer that suppresses combustion of the fibre. This effect resists the formation of a carbon track between electrodes when an electric arc passes over the surface.

All grades of Spaulding Vulcanized Fibre have these properties. However, the greater density of Spaulding Supergrey (Bone Grade) provides them to a superior degree.

Applications

In addition to the applications noted in Figures 1 and 2, Spaulding Vulcanized Fibre is especially suited for these uses:

• Fibre properties which cause it to be non-arc-tracking and arc extinguishing, lead it also to resist igniting under short term, high temperature arcs such as might be encountered in the burning of a fuse link or when used as an arc shield.

• Fuse cases of solid wall fibre tubing for inside fuses and as an inner liner in Spauldite tube cases for pole line outdoor fuses exposed to weather. This takes advantage of the structural strength of Vulcanized Fibre tube in addition to the resistance to igniting characteristics.

• Both oil switches and oil circuit breakers designed to interrupt high power currents take advantage of the arc extinguishing properties of Vulcanized Fibre by drawing the arc through narrow and circuitous channels in the fibre baffle stacks.

• Perhaps the most spectacular use made of the deionizing properties of Vulcanized Fibre is in the lightning surge arrester units of the expulsion type. These are now available in many types, all based upon the principle of conducting the lightning discharge to ground through an external and internal gap. In the latter, the arc chamber provides small passageways in the Vulcanized Fibre designed to extinguish the arc in microseconds to prevent power current from following through to ground.

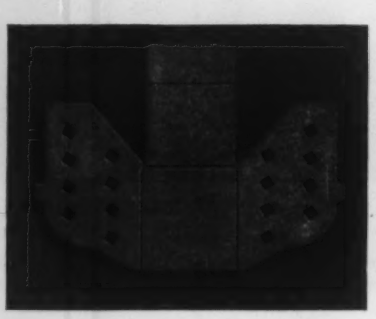


FIGURE 1. The arc extinguishing properties of Spaulding Vulcanized Fibre are used in distribution switches and small circuit breakers where opened contacts draw the arc close to the fibre surface where it is extinguished.

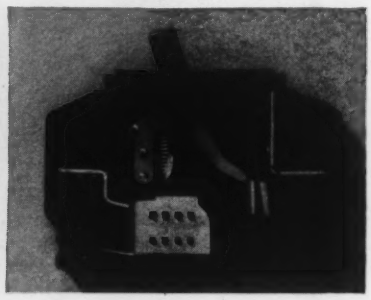


FIGURE 2. In the widely used circuit breaker, a combination of metal grids held within a framework of Spaulding Supergrey Fibre is economical and effective in snuffing the arc. Serving the same purpose as a fuse it has the advantage of quick re-use after cutting the circuit.

SPAULDING VULCANIZED FIBRE SHEETS *PHYSICAL PROPERTIES*

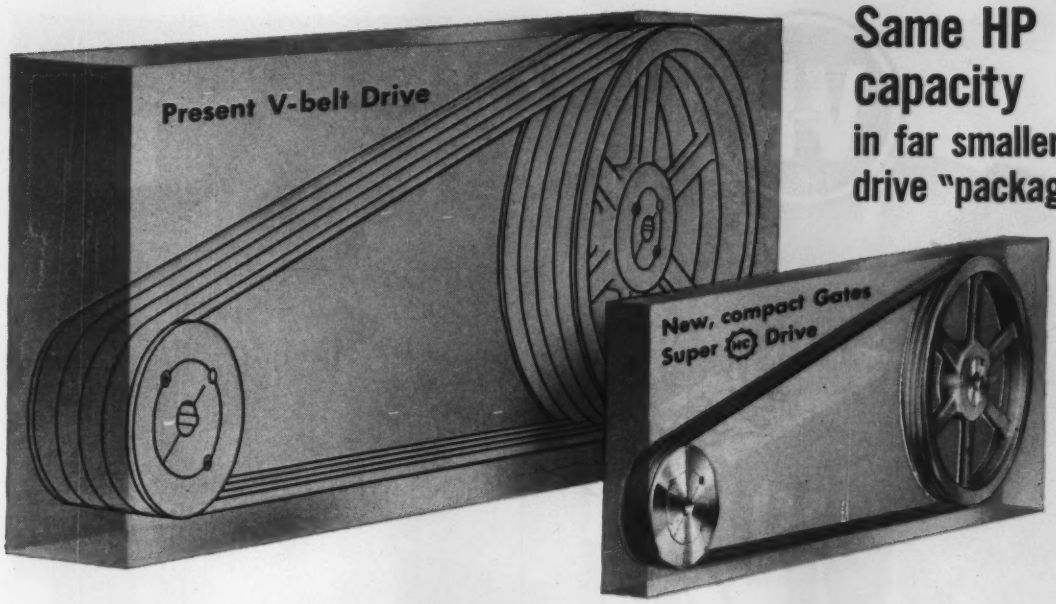
PROPERTY	THICKNESS INCHES	COMMERCIAL GRADE For Mechanical and Electrical Use		BONE GRADE SPAULDING SUPER GREY Highest Density Maximum Hardness	
Tensile Strength P.S.I. Typical	1/8 to 1/2 incl.	Crosswise 7,500	Lengthwise 12,000	Crosswise 7,500	Lengthwise 12,500
Flexural Strength P.S.I. Min.	1/8 to 1/2 incl.	Crosswise 12,000	Lengthwise 14,000	Crosswise 13,000	Lengthwise 15,000
Izod Impact — Ft/lbs per in. of Notch, Min.		1.2	1.6	1.0	1.4
Density — G. per Cu. Cm. Min.	Over 3/32 to 4/8 incl.	1.20		1.30	
Water Absorption Change in Wt. % Max.	1/8	2 Hr. 35	24 Hr. 61	2 Hr. 20	24 Hr. 48
Dielectric Strength Volts per Mil. Min.	Over 1/8 to 3/8 incl.	100		100	

Low heat conductivity oil, grease and solvent resistant, light weight, tough, resilient, high mechanical and electrical properties, easily machined and formed, wear resistant, economical.

Write for a free copy of Spaulding's new booklet, "Vulcanized Fibre Engineering Data"

SPAULDING FIBRE COMPANY, INC.

320 Wheeler Street Tonawanda, New York



Same HP capacity in far smaller drive "package"

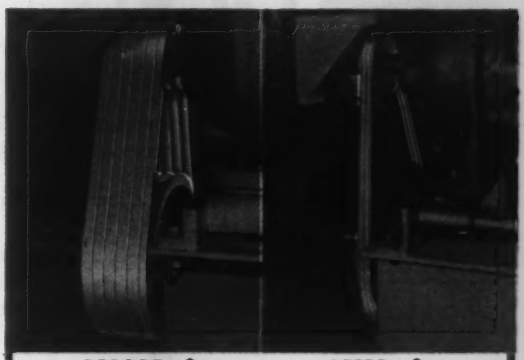
New high capacity V-belt cuts drive cost as much as 20%

Reduce size, cut costs! Gates new Super HC V-Belt Drive puts power transmission in a smaller package—cuts costs all along the line!

With Gates Super HC V-Belt Drives you use fewer belts, smaller sheaves. Sheave diameters and widths are reduced 30% to 50%; center distances 20% and more; weight is substantially reduced. *Initial drive cost is cut as much as 20%.*

Furthermore, as every designer knows, a more compact drive insures other savings, too. Smaller housings, bearings, bases and other components cost less; machining time is often reduced; shipping costs are lowered. And finally, the ultimate user gets the benefit of lower *maintenance* costs—less down time!

"The Modern Way to Design Multiple V-Belt Drives" is an informative handbook on Gates major advance in power transmission—the Super HC V-Belt Drive. Your nearby Gates Distributor—listed under Belts or Belting in your phone book Yellow Pages—will be glad to furnish a copy of this handbook.



BEFORE ◄ ► AFTER

COMPARE: Conventional drive at left was replaced with Gates new Super HC V-Belt Drive at right. Three of Gates new, narrow HC V-Belts do the work of the former 6 standard width belts. In this application the new drive actually takes *one-third* the space of old!

TPA 391

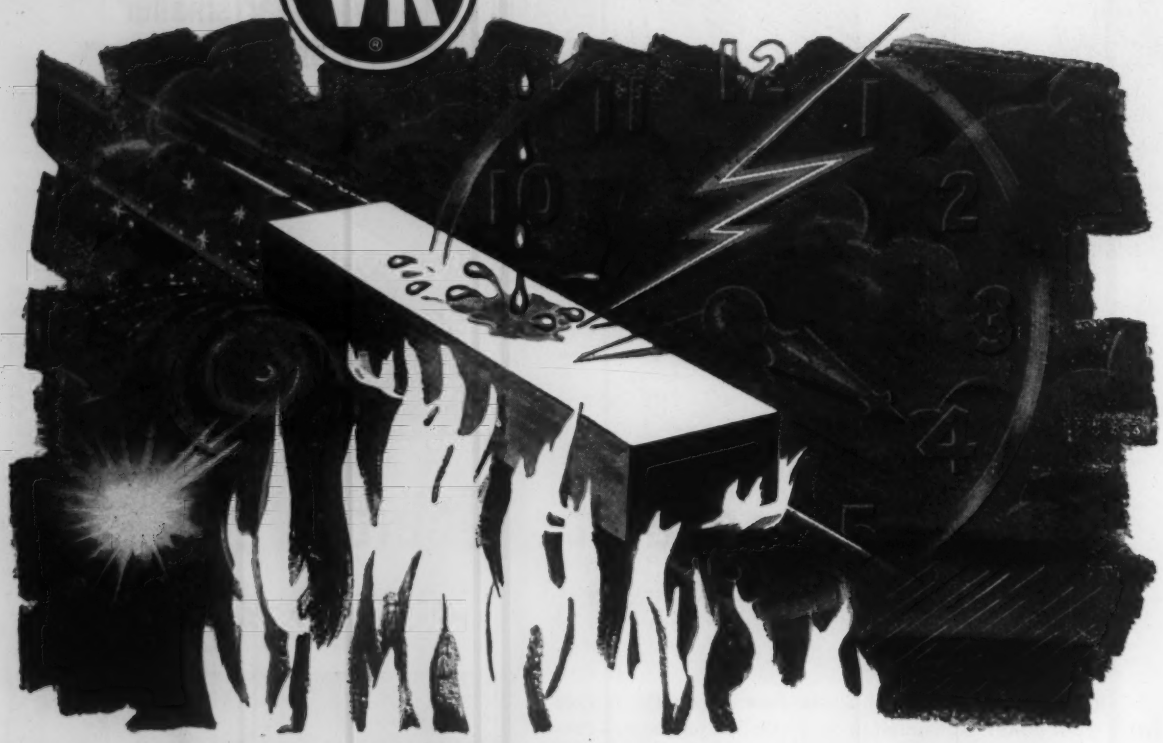
Gates

World's Largest Maker of V-Belts

The Gates Rubber Company • Denver, Colorado
Gates Rubber of Canada Ltd., Brantford, Ontario

Gates Super HC V-Belt Drives

V-R Metals...



where DURABILITY is needed!

Metals of tomorrow ...TODAY!

Vascoloy-Ramet Corporation is a pioneer manufacturer of refractory metals . . . making its substantial contribution to America's growth by developing special metals with exceptional characteristics to meet the changing needs of industry.

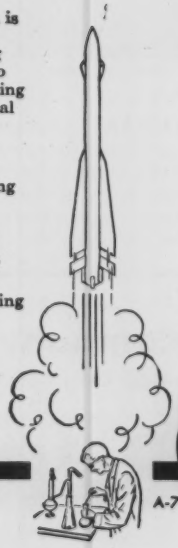
29 years of V-R research, engineering and manufacturing experience . . . covering thousands of application problems . . . have produced the technical know-how built into all V-R products.

This same know-how is working full time, developing new refractory metals, to meet tomorrow's needs.

Seconds . . . hours . . . years . . . how long must a part last when designed to do a job? Exceptional qualities of V-R metals can help you solve many design problems. Resistance to wear and corrosion . . . high density . . . stability at extreme temperatures . . . rigidity under a given load . . . low coefficient of expansion for greater dimensional uniformity . . . good surface finish obtainable (less than one micron) . . . are some of the characteristics of metals that V-R makes available to the designer.

These properties can be produced in various combinations in sintered or alloyed metals to fill specific performance needs. Parts can be designed in shape and form to give optimum use of the metal.

Use V-R metals in the parts you design to assure durability and dimensional stability. Call your nearest V-R representative or send us the details of your requirements.



V-R Vascoloy-Ramet corporation

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here's a 3-POINT PROGRAM for lower cylinder costs

Cut inventory costs

to a minimum by taking advantage of fast deliveries from Hydro-Line factory stocks. Over 90% of all cylinder applications fall into the thousands of bore, stroke and cushion combinations ready for immediate shipment. Series R2 cylinders rated at 200 psi air and 500-2500 psi hydraulic; Series S2 cylinders rated at 200 psi air and 1000 psi hydraulic; Series N cylinders rated at 2000 psi and higher.

Pare maintenance costs

by taking advantage of the cylinders that not only require fewer downtime periods in every class of service, but also are faster and easier to service on the job without special tools or equipment.

Save 42-1/2% by specifying R2 Series

Specifying this design instead of high-pressure hydraulic cylinders will give you these, or even greater, savings. You can save even more by specifying stock cylinders. By choosing Hydro-Line you can eliminate specials on almost all jobs. All three series — R2, N, and S2 — meet J I C specifications.

Just fill in the coupon below to get bulletins containing more data or contact your nearby Hydro-Line representative.

act now!

Please send me additional data on the classes of Hydro-Line cylinders checked below, including complete information on deliveries from factory stocks:

( ) Series R2 (heavy-duty air, medium-duty hydraulic, industry standard)
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Company _____
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HYDRO-LINE MANUFACTURING COMPANY
5602 PIKE ROAD ROCKFORD, ILLINOIS

HL HYDRO-LINE CYLINDERS

5602 PIKE ROAD • ROCKFORD, ILLINOIS

manufacturers of: high- and low-pressure hydraulic cylinders • heavy-duty air cylinders • adjustable-stroke cylinders • dispensing cylinders • intensifiers • single-acting cylinders • booster cylinders

Tiny Living Heat Exchangers. Some species of deep sea fish have countercurrent bundles of blood vessels (rete mirabile, shown twice actual size) so efficient that if boiling water and ice water were counterflowing in them, heat transfer would be complete to 1/10,000 of a degree!

Miniature Pressure Transducer for airborne instrumentation, 1″ long, 1″ O.D., withstands accelerations in 3 planes up to 40g with error less than 1%. Utilizing low-torque characteristics, 2 MPB bearings provide capacity, life and maintain exacting precision of a sensitive linkage.

Man With Miracles. This is Harry Marschausen, one of MPB's Sales Engineers. Through men like him, MPB's extensive engineering experience and design consultation are readily available to all industry. When your application requires a miracle in miniaturization, call in your MPB man.

Miracles in Miniaturization Continue

ACTUAL SIZE OF THE BEARINGS IN PRESSURE SWITCH SHOWN ABOVE

Man is making fabulous progress in his ceaseless fight against friction and inertia. Today's machines operate at fantastic speeds and accelerations . . . on earth . . . in the sky . . . and beyond. But space for components daily becomes more precious and while bearings used in these machines must have tremendous stamina, many of them must be almost unbelievably compact. MPB makes over 500 types and sizes of such bearings ranging down to 1/10″ O.D. Send for illustrated catalog describing them. Special bearings supplied when necessary. Design assistance at your request. Write **Miniature Precision Bearings, Inc.,** 108 Precision Park, Keene, N. H.

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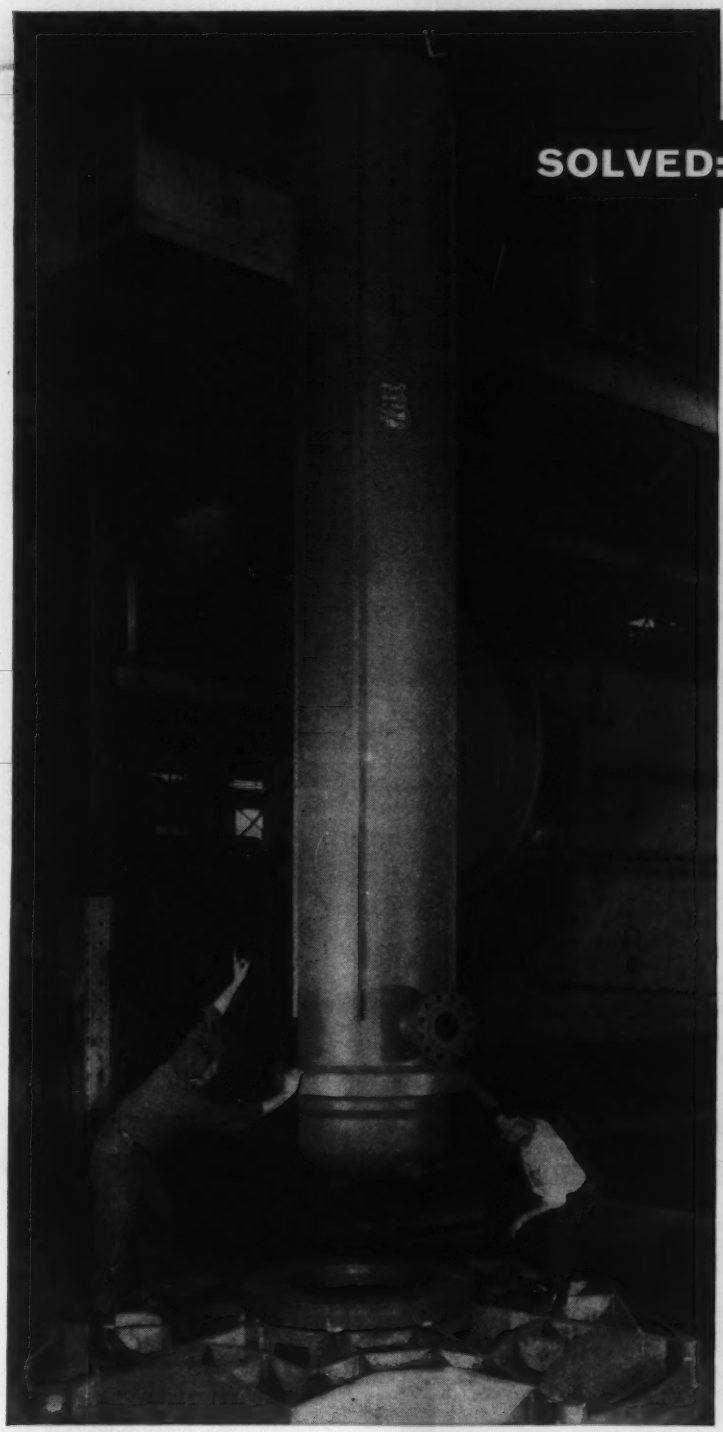
BEARINGS, INC.

Helps you perform miracles in miniaturization

Circle 482 on Page 19



Blaw-Knox workmen assembling one of two constant pressure type accumulators built for two of America's largest steel mills. Sandusky supplied the straight cylindrical sections for both.

SOLVED: by Sandusky Centrifugal Casting

Blaw-Knox chooses 10-ton

SANDUSKY CASTING

for giant slabbing mill

When an 18½-foot cylinder was needed for a new giant Universal slabbing mill built by Blaw-Knox Company's East Chicago (Indiana) Works for a well known steel mill, they found that the most practical and economical way to meet all requirements was with a Sandusky Centrifugal Casting.

This 10-ton carbon steel cylinder, 32" O.D. with a 3¾" wall, functions as an accumulator in the mill's hydraulic roll balancing system. Essentially a pressure vessel, it simultaneously supports the ram and ballast weighing 226 tons—the weight required to develop constant operating pressure of 1000 p.s.i.

"Only a dimensionally stable, one-piece cylinder could perform satisfactorily in this service," a Blaw-Knox official asserted. *"Distortion could lead to binding, loss of pressure and costly downtime. Sandusky's ability to produce this heavy walled cylinder in one 18½ foot length met all our requirements of cost, stability, and strength."*

Sandusky cylinders up to 33 feet long —from 7" to 54" O.D.— and in a wide range of ferrous and non-ferrous alloys —may well be the answer to *your cylindrical problems,* too.

Write to us at Sandusky, Ohio. Ask for latest Bulletin #200.

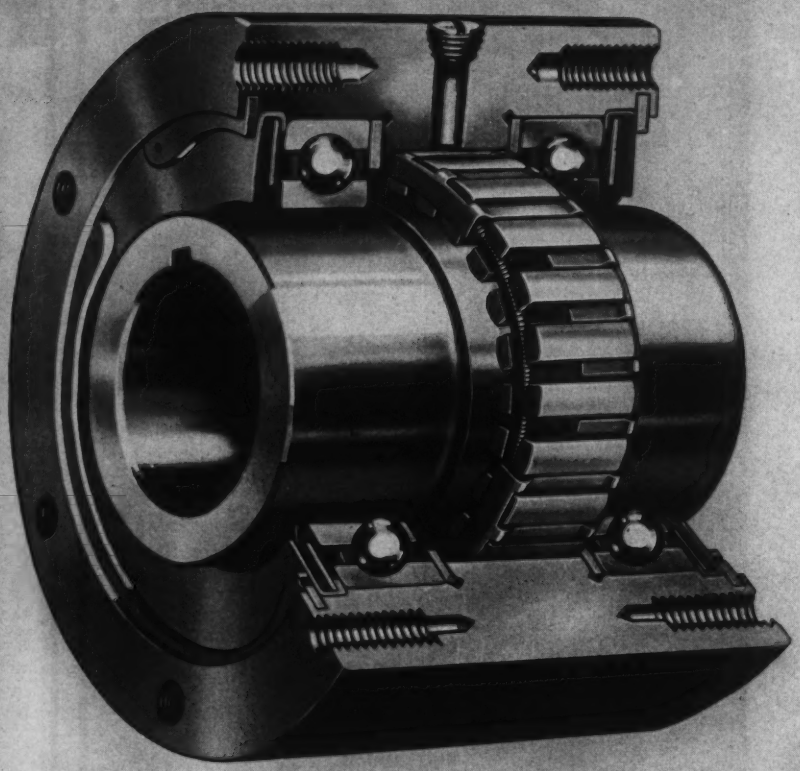
SANDUSKY CENTRIFUGAL CASTINGS

FOUNDRY & MACHINE CO.

8901

SANDUSKY, OHIO—Stainless, Carbon, Low-Alloy Steels—Full Range Copper-Base, Nickel-Base Alloys

NEW! HIGH-PERFORMANCE



This is a high-performance Formsprag clutch having a torque capacity of 475 lbs. ft. and a 1.25" bore diameter. Note sprag and retainer design that assures coordinated yet free-action movement of sprags. Positive sprag engagement, greater torque capacity, higher speed applications and longer clutch life result from this new design.

OVER-RUNNING · INDEXING BACKSTOPPING

COMPARATIVE PERFORMANCE CHARACTERISTICS

1. *Longer Life*—Running at identical speeds, an HPO clutch with Formchrome sprags will give you up to 70% longer life than a comparable standard Formsprag over-running clutch.
2. *Increased Speed*—HPO clutches using Formchrome sprags can be operated at up to 30% higher R.P.M. with same life span as a comparable standard Formsprag over-running clutch. Also, the HPO clutch design can be modified for special applications requiring high over-running speeds up to 20,000 R.P.M.
3. *High-Performance Indexing*—Here's a typical example that is characteristic of the entire HPI line. On 15° indexing, a Formsprag HPI clutch with a torque capacity of 475 lbs. ft. can be operated at 1,200 indexes per minute without slip or backlash.

For further information on these High-Performance Over-running and Indexing clutches, send for descriptive brochure.

HERE'S

The Formsprag clutch consists of a full complement of shaped sprags, or wedges, located between concentric inner and outer races. Power is transmitted from one race to the other by the wedging action of the sprags. Each sprag is so shaped that dimension AA is greater than BB. Rotation of one race in the "driving" direction causes the sprags to wedge, transmitting torque in full from one race to the other.

FORMSPRAG CLUTCHES

FOR OVER-RUNNING · INDEXING

Formsprag clutches have always provided greatest torque for size and weight, higher precision, no measurable backlash and long, trouble-free life. However, designers and users often have applications for over-running and indexing clutches where even higher performance characteristics are required.

To meet this need for super-performance, Formsprag has perfected a new line of High-Performance Over-running (HPO) clutches and a new line of High-Performance Indexing (HPI) clutches.

The HPO and HPI clutches have an improved sprag design and retainers that assure a coordinated movement of all sprags but each sprag also has a free-action feature. The design assures: positive engagement of every sprag—uniform distribution of driving load over all sprags—greater torque capacity for clutch size. This same "Free-Action" operation of sprags also assures there will be a minimum of drag on all sprags during over-running. Result, clutch can operate at higher speeds, there is less wear on all clutch components and longer clutch life is obtained.

There is a Formsprag clutch size and model for every application—from business machines to aircraft. HPO, HPI and standard FS clutches are completely described in a new brochure, write for your copy.

FORMSPRAG COMPANY
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Warren (Detroit), Michigan

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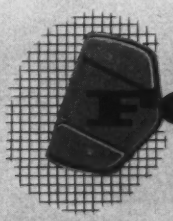
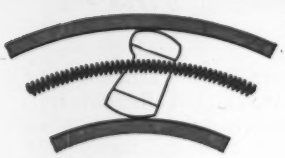
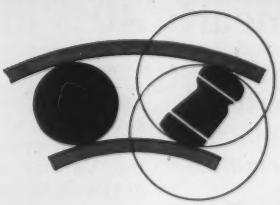


FORMSPRAG CLUTCHES

World's Largest Exclusive Manufacturer of Over-running Clutches

HOW IT WORKS

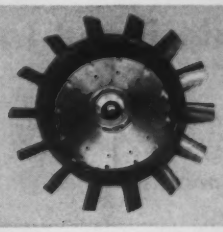




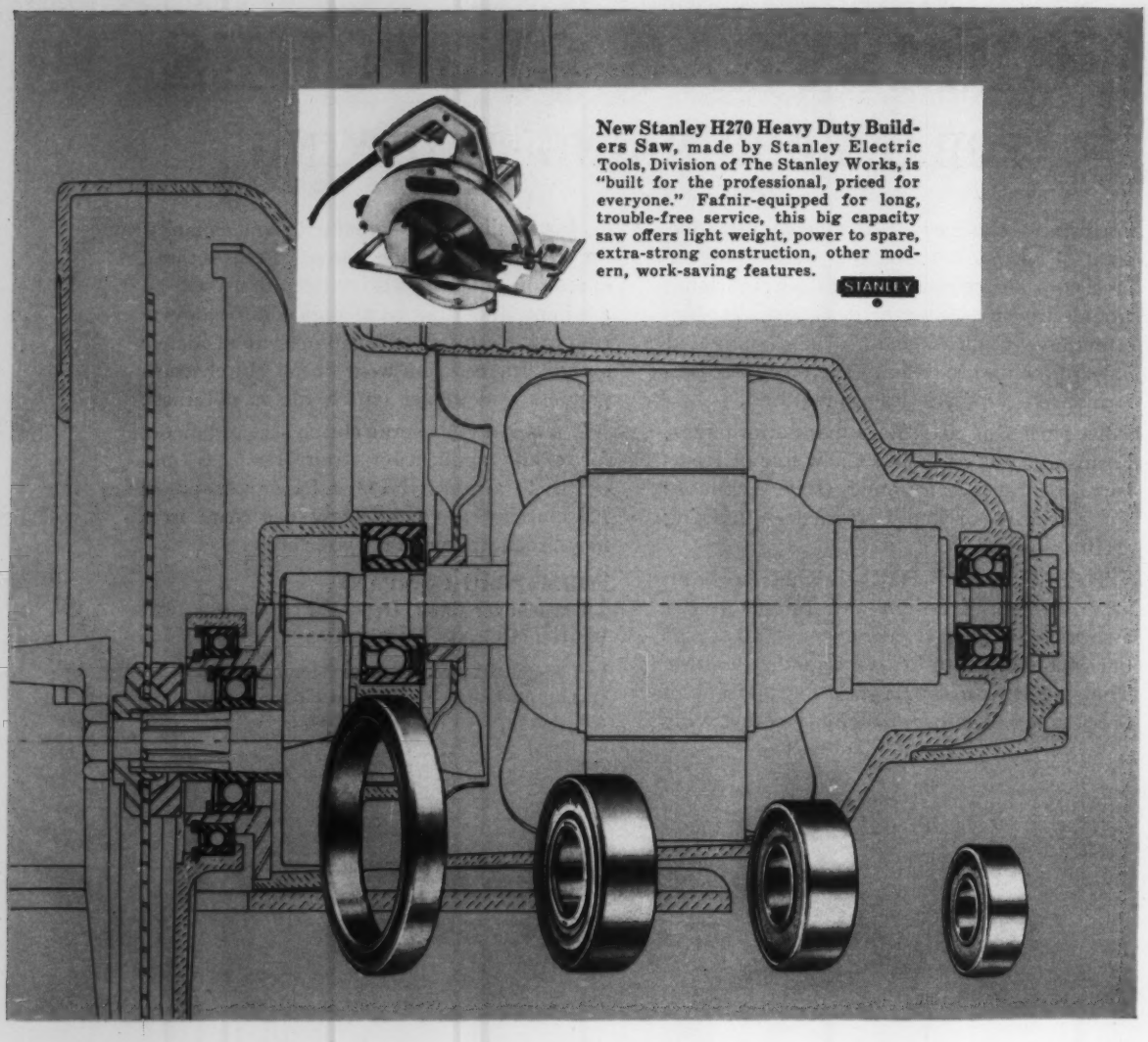
An expanding coil spring keeps the sprags in light contact with both inner and outer races. There is thus no lost motion, the driving torque being instantaneously transmitted between races. The Formsprag Clutch is so designed that it will transmit a greater torque in relation to its size and weight, than any other comparable type of clutch . . . specify Formsprag on over-running, back-stopping and indexing applications.

Forcing a ball or roller into a curved, wedged space is an old over-running clutch principle. The sprag is, in effect, a "roller" of increased diameter with greater contact surface in a given annular space. Formsprag Clutches engage at constantly changing contact points. Clutch life is prolonged and backlash eliminated. Also, with the inclined surfaces discarded, more sprags can be inserted to increase torque capacity.

RAWSON FOR NO-LOAD STARTS



The compactness, reliability and maximum capacity of Rawson Clutches have proven especially effective in aircraft applications such as helicopter transmissions. Used in a wide variety of other applications, Rawson Clutches eliminate costly reduced voltage starting equipment, permit use of lower cost smaller motors and provide full overload protection. Write for your copy of Rawson Clutch Catalog.



New Stanley H270 Heavy Duty Builders Saw, made by Stanley Electric Tools, Division of The Stanley Works, is "built for the professional, priced for everyone." Fafnir-equipped for long, trouble-free service, this big capacity saw offers light weight, power to spare, extra-strong construction, other modern, work-saving features.

STANLEY

New Stanley power saw, Fafnir ball bearing equipped, designed to deliver nearly 40% more cutting force!

Armature, saw shaft, even the blade guard Fafnir-mounted for free-starting, no-maintenance, heavy-duty performance

Nearly 40% more cutting force at working speeds, with 27% less operator effort! This new Stanley power saw represents a design achievement of the first order. And to insure long, efficient service life, Stanley makes generous use of Fafnir precision ball bearings. Even the blade guard is Fafnir-equipped (with an aircraft type bearing), for responsive action at the slightest pressure. On the armature and saw shaft, Fafnir ball bearings all but eliminate friction and wear. Bearing maintenance is eliminated, too. Various combinations of seals and shields lock out contaminants, lock in factory-packed lubricant. No danger of faulty or neglected lubrication... virtually no chance of bearing failure.

Take advantage of Fafnir's "designer's approach" to bearing problems. You'll find Fafnir's breadth of experience and diversity of line insure precise answers. Write The Fafnir Bearing Company, New Britain, Connecticut.

Sealed and shielded Fafnir ball bearings meet specific service requirements in Stanley saws

Felt seal and shield (Motor Armature)

2 Flya-Seals (Blade Guard)

Flya-Seal and shield (Saw Shaft)

FAFNIR BALL BEARINGS

Circle 485 on Page 19

NEW... adjustable 3/4" Deceleration Valve

Simplifies Cam Design, Cuts Set-up Time, Eliminates Need for Special Valve Spools

These Features are Important to You:

- Controlled deceleration regardless of flow rate
- Reduces set-up time—eliminates experimenting with cam shapes
- One valve can handle all applications from 5 to 25 gpm giving greater flexibility
- Regulates initial deceleration pressure—eliminates wasted spool movement
- Can be used for applications to 60 gpm without malfunction
- Includes adjustable by-pass needle valve
- Available with or without check for reverse free flow
- Threaded ports or subplate mounting

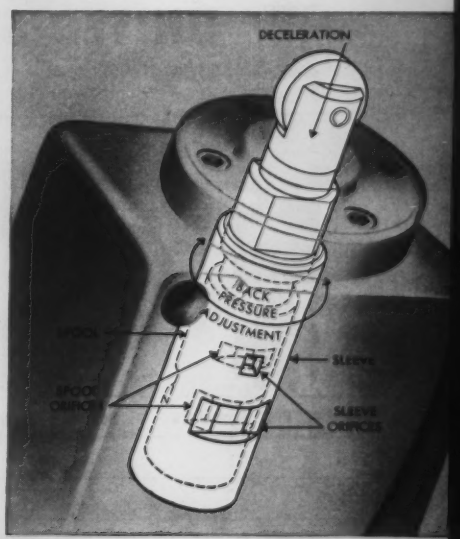
TYPICAL USES:

1. Converting rapid traverse motions to slow, controlled feeds.
2. Rotary indexing operations. Will control deceleration and permit creep to accurate final position.
3. Straight-line transfers. Deceleration control gives smooth stop without excess movement of part being transferred.

Write for installation drawings No. 214322 and 1-214323.

Orifice size (through spool and sleeve) is made larger or smaller by rotation of sleeve. Adjusting screws on the face of the valve rotate the sleeve to the required orifice opening. Deceleration stroke length remains unchanged. No special cam shape is required for valve spool travel.

Patent Pending.



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8276

ENGINEERS AND BUILDERS OF OIL HYDRAULIC EQUIPMENT SINCE 1921

Circle 486 on Page 19

can keep you up on keeping gauge costs down

If you have a new product coming up, or design changes for a present product, and need *any* type of pressure gauge . . . you will get your gauge faster and save more by checking United States Gauge first. For these reasons:

First, USG has 50,000 standard gauges to draw on. Second, USG knows thousands of modifications possible with standard gauges to meet special design requirements more economically. Third, the men at USG know your competitive need to design better performance into equipment and deliver faster, while reducing costs.

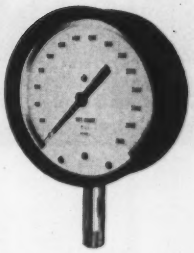
Finally, at USG you will get exactly the gauge accuracy and performance you want for your purpose and price . . . up to and including the finest high-precision test gauges made.

Today, USG gauges are specified by 6 out of 10 original equipment manufacturers. For a closer look at dependable performance and lower costs in your next gauge need, call your USG distributor, listed in the Yellow Pages. Or write direct to United States Gauge.

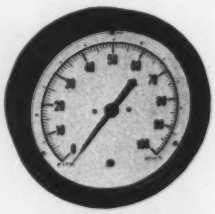
UNITED STATES GAUGE

Division of American Machine and Metals, Inc., Sellersville, Pennsylvania

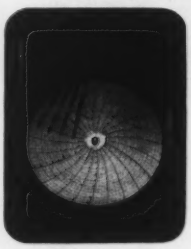
Find Your Nearest Distributor in the "Yellow Pages"



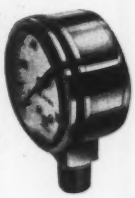
Test Gauges



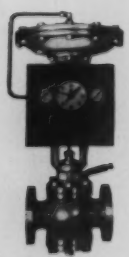
Pneumatic Receivers



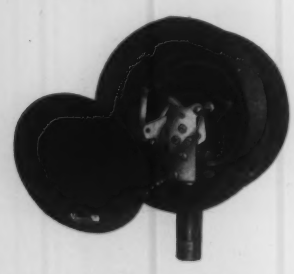
Recorders and Recorder-Controllers



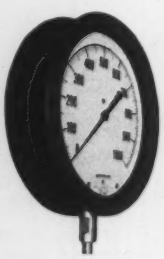
Drawn Case Gauges (Brass or Steel)



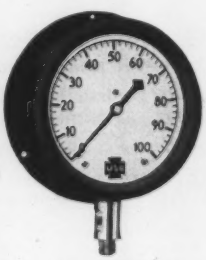
Indicating "Pilot" Controllers and Transmitters



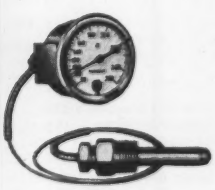
Solfrunt® (Supergauge) with blow-out back



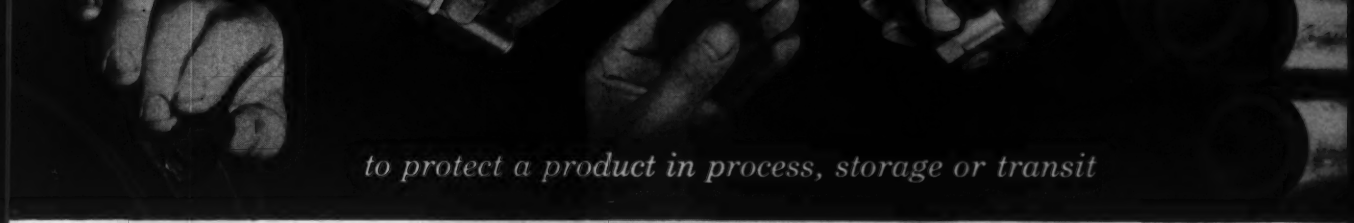
Supergauge® (A.S.A. Grade AA) Line



A-Line (A.S.A. Grade A) Gauges



Drawn Case Thermometers, too



to protect a product in process, storage or transit

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PRESSURETROL*
PRESSURE CONTROLLERS

Here are new additions to Honeywell's broad line of pressure switches designed specifically for industrial use. Use them for reliable, economical control of liquid or gas pressure—alone as controllers, or with other instruments for limit alarm or signalling service.

1. MODELS P428A, B, C, D FOR CONTROL OF PRESSURES TO 3000 PSI

These *Pressuretrols* consist of a single-pole, single-throw mercury switch operated by a corrosion-resistant Bourdon tube. The case is designed to harmonize with other instruments, and is ideal for use in panels. It is compact, of drawn steel with a die-cast cover, and resists dust, weather and corrosion. The *Pressuretrol* can be surface or flush mounted on a panel or installed directly on a pipe. Pressure settings are made with two knobs conveniently located on the face of the unit.

SPECIFICATIONS

MODELS: P428A, standard case, spst, breaks circuit on pressure rise.
P428B, standard case, spst, breaks circuit on pressure fall.
P428C, explosion proof, spst, breaks circuit on pressure rise.
P428D, explosion proof, spst, breaks circuit on pressure fall.

Pressure Ranges	Maximum Pressures	Bourdon Tube
30— 300 psi	375	Bronze or stainless steel
50— 600 psi	750	Bronze or stainless steel
100—1000 psi	1200	Beryllium copper or stainless steel
200—2000 psi	2400	Beryllium copper or stainless steel
300—3000 psi	3500	Beryllium copper or stainless steel

2. MODELS P444A, B FOR INDEPENDENT HIGH AND LOW PRESSURE SETTINGS

Use these *Pressuretrols* in a wide variety of industrial applications that call for independent high and low pressure settings and switching action. A pressure-actuated, corrosion-resistant stainless steel diaphragm positions a mercury switch according to selected pressure settings. The mercury switch, scale plate and pressure setting indicators can be easily seen through a protective glass window in the cover. Pressure setting handwheels extend through slots in the cover. Adaptable for either surface or flush mounting.

SPECIFICATIONS

MODELS: P444A, standard case, spst, breaks circuit on pressure rise.
P444B, standard case, spst, completes circuit on pressure rise.

Range	Maximum Pressure
20" vac.—40 psi	75 psi
1—20 psi	50 psi
5—60 psi	80 psi
5—150 psi	200 psi

Get complete details from your nearby Honeywell field engineer. Call him today . . . he's as near as your phone.

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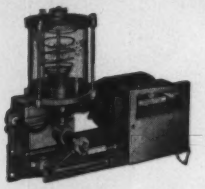
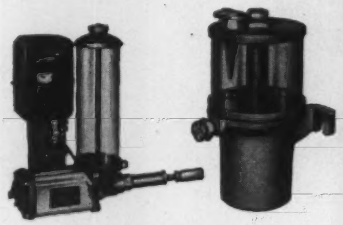
Circle 489 on Page 19

NEW LINCOLN CENTRALIZED LUBRICATION SYSTEMS



ELECTRO-LUBERS

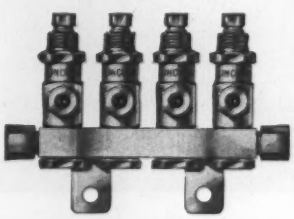
Compact, efficient electric-powered lubricant pumps supply oil or grease to banks of injectors in a centralized system. Become integral part of individual machine on which installed, providing routine self-lubrication.



RAM PUMPS

High or Low Volume Output

Low-cost, easy-to-install. Systems designed to provide automatic or semi-automatic lubrication of bearings, simultaneously, on single machine units while in operation. May be actuated mechanically, electrically, or manually. Dispense oil or grease.



MICRO-MEASURE SYSTEM

Miniaturized system pre-measures and injects fluid lubricants to millionths of an ounce, providing a totally new type of automatic lubrication. Can be automatically cycled as often as once every 3¾ minutes. Insures constant application of pure lubricant adjustable to individual bearing requirements. Can save more than its total cost in a few weeks.

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A REPORT TO MANAGEMENT
* How modern lubrication methods can reduce operating costs and improve production
Another service to industry from Lincoln Engineering Company Saint Louis

Complete facts on HOW CENTRALIZED LUBRICATION ADDS EXTRA SALES APPEAL TO YOUR ORIGINAL EQUIPMENT

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Filter Application: **PROTECT HYDRAULIC CONTROLS**

Filter: **PUROLATOR**

The Polaris and the nuclear powered submarines which will carry and launch it form a mobile striking force that commands respect. Wherever they may be, it is imperative that, when the signal is given, the Polaris takes off and goes straight to the target.

Hydraulic control circuits play an important role in the programmed flight of the Polaris. To insure against malfunctions in the circuits, Purolator filters are designed as an integral part of many of them, to specifications set by Lockheed Missiles and Space Division, Polaris missile system manager.

Purolator engineers will gladly bring to your needs the filtration knowledge they provide for Polaris and other top-priority projects. A letter or phone call describing your aircraft or missile filtration requirements will receive prompt attention.

Filtration For Every Known Fluid

PUROLATOR

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SINGLE PACKAGE FRACTIONAL HP AJUSTO-SPEDE® DRIVES

Provide Stepless Adjustable Speed from an AC Power Source

STANDARD

WITH FRICTION BRAKE

WITH SPEED REDUCER

Sizes and Types for Hundreds of Industrial Applications

Dynamatic Ajusto-Spede® Drives, part of a family of diversified eddy-current equipment, provide an economical solution to many adjustable speed drive problems.

The Fractional Horsepower Ajusto-Spede, a single package design, combines an AC constant speed induction motor, eddy-current coupling, and electronic control. Standard modifications provide for the addition of electrically operated fail safe friction brakes, or speed reducers with numerous gear reduction ratios.

Fractional Horsepower Ajusto-Spede Drive power is taken directly from 115/220 volt, single phase or 220/440 volt, 3 phase lines. Sizes are ¼, ⅓, ½ and ¾ horsepower at 1600 RPM; ½, ¾ and 1 horsepower at 3200 RPM.

Friction brakes for quick stopping or fast cycling operation are furnished in two capacities—1½ and 3 pounds feet of torque.

Gear reductions with 10 ratios between 5-to-1 and 100-to-1 are supplied with 1600 RPM and 3200 RPM Ajusto-Spedes.

Ajusto-Spede® Advantages

- ★ **Constant torque speed range: 25 to 1 with either 1600 RPM or 3200 RPM Ajusto-Spedes.**
- ★ **Control accuracy: 2 per cent of top speed at any point within the speed range.**
- ★ **Minimum wiring to power line.**
- ★ **Remote "one knob" control operation up to 100 feet.**
- ★ **Rugged plug-in type integral one-tube electronic control.**
- ★ **Permanently sealed grease-packed bearings.**

For more detailed information, write for your free copy of the Dynamatic Fractional Horsepower Ajusto-Spede Bulletin, FAS-6.

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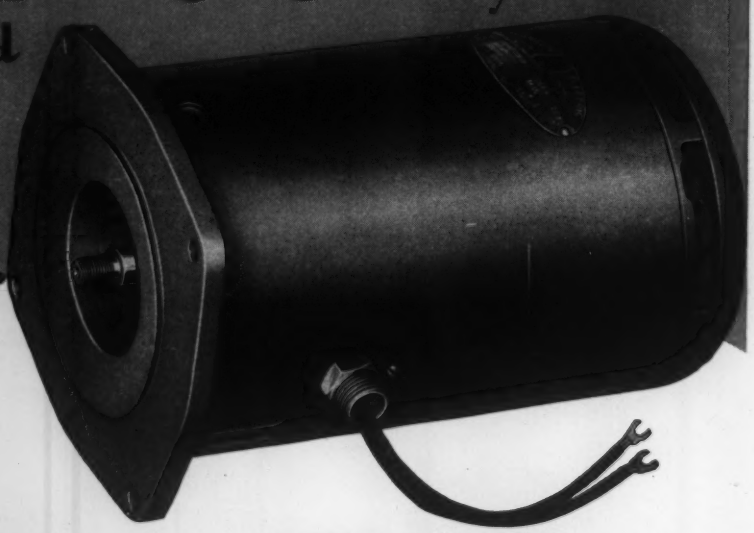
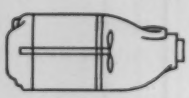
Circle 492 on Page 19

UNISEAL MOTOR *by* Franklin

...Franklineered *to improve pumps and other powered products*

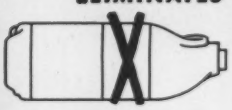


CUTS ASSEMBLY TIME



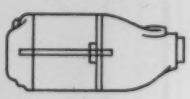
Pump impeller fastens to motor shaft, eliminating stub shaft, couplings and outboard bearings. Fewer parts, less assembly labor.

ELIMINATES ADAPTER CASTING



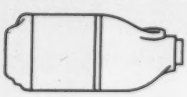
Seal cavity in end-casting enables mounting of pump without adapter casting. Reduces labor cost and parts inventory.

S/S MOTOR SHAFT IS RUSTPROOF



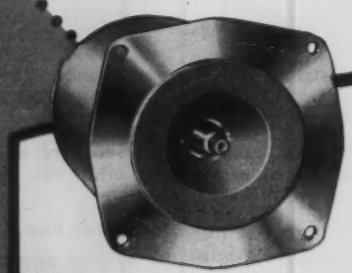
Corrosionproof stainless steel shaft guards against excess wear and seal leakage. Improves performance and longevity.

TOTAL WEIGHT IS GREATLY REDUCED



Integrated pump and motor save space and weight. Franklineering improves product appearance and performance, and cuts costs.

Precision-machined surfaces of mounting end are concentric with shaft to assure proper alignment of motor with powered product. Application-engineered to fit your products, the Uniseal Motor is available with or less base. Operates in horizontal or vertical position.



Franklineering...

describes Franklin Electric Company's advanced methods employed in design and production of application-engineered motors. Manufacturers who incorporate these motors with their products enjoy cost advantages in addition to superior performance. In the competitive water system market, leading manufacturers prefer dependable Franklineered Motors to provide product reliability.

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THE DODGE STEEL ladle
BUSINESS MAGAZINE EDITION
PUBLISHED BY DODGE STEEL COMPANY
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If your activities involve product design and development, purchasing, production . . . or management, you should know about the complete manufacturing service offered by Dodge Products.

This unique division of Dodge Steel Company was originally established for the purpose of machining quality steel castings as an additional service to its customers. However, diversification has multiplied its products and services until today, there is hardly an industry that is not benefiting in some degree, from the research, development and experience of this manufacturing organization.

A COMPLETE SERVICE

Dodge Products offers you a complete manufacturing service in the literal sense of the word . . . *from idea to finished product*. This service extends from product design engineering and development—through the machining and fabricating of just about any metal or material—to the production of finished parts, components or products.

MULTIPLE SAVINGS

The services offered by Dodge Products are streamlined to save time, trouble and money for you. When parts or components are fabricated by us, you relieve yourself of production and labor problems. Mistakes, rejects, machinery breakdowns are *our* headaches. The scrap problem is *ours*. You have only to receive and give final inspection to the finished parts. These are delivered *on time*, ready for your production line.

SCOPE OF SERVICE

Here are just a few of the many services and facilities available to you:

- Product Design & Development
- Milling and drilling
- Turning in all metals
- Boring—horizontal and vertical
- Welding—all types
- Plating and painting
- Jigs and fixtures
- Production tapping
- Bending
- Shaping
- Long or short production runs
- Casting and patternmaking
- Hydrostatic testing
- Magnaflux and X-ray testing
- Drafting
- Strain Laboratory

Like to know more about this unique custom manufacturing service? This new bulletin describes in detail the many services we offer. Write for a free copy today.

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If you are looking for new ways and means to improve your product, and save money too, here's an idea source guaranteed to spark your imagination and give you a wealth of hints, tips, and suggestions.

The Dodge Steel Ladle is an 8-page, quarterly magazine. It contains how-to-do-it articles on steel castings . . . "case history" examples of how castings are used in industry . . . informative discussions on how castings are made . . . news about developments in Dodge Products. And, that's not all! There's a lot more information as well . . . data that you'll find of constant value and interest. Like to be put on the mailing list? Just tell us and we'll do the rest. No obligation, of course.

NYLOK FASTENERS lock and seal by means of a tough nylon pellet embedded in the body of the fastener. Locking and sealing action is sustained, because the nylon attempts to return to its original shape when deformed. Nylok fasteners make excellent adjustment screws, oil pan and gear case bolts.
LOK-THRED meets conditions of severe vibration, tension, torsion, thermal loading. Lok-Threds can never back out, fret or shake loose. Because of its unique reforming and intimate metal to metal contact, Lok-Thred seals effectively in practically all metals. Widely used on engines and motors of all sizes and types.
PLACE BOLTS have a built-in spring action in the head of the bolt. This provides a safety margin of additional elastic elongation, and greatly reduces danger of fatigue failure in addition to locking. Place Bolts can be used wherever Cap Screws are used, and effect real savings in most applications.

Which self-locking fastener?

Lamson makes all three, helps you cut costs, not corners

Nylok. Lok-Thred. Place Bolt. All are variations on the same theme. However, one of the three will be better suited to your application. One will lower your assembly cost more than the other two. Which one?

Because Lamson makes all three self-locking fasteners . . . standards and specials . . . Lamson engineers are anxious (and able) to recommend the one that's best for you. That helps you make a better product. That helps you cut costs... not corners. Contact a Lamson Sales Engineer for details.

SEND FOR ENGINEERING DATA

Gentleman: Mail engineering data on Place Bolts ☐ Lok-Thred ☐ Nylok ☐

Have nearest Sales Engineer call for appointment ☐

Application we're considering is _____

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RICHIE DESIGN
August 20, 1959

Know the Rules!

THE day this issue came off the presses, a package was put in the mails to the Library of Congress, Washington, D. C. Its content: Two copies of the magazine and a 4-page printed form. Its purpose: Copyright protection of this issue and its contents.

By this simple procedure, the unique product of the combined efforts of a crew of editors, authors, artists, and all the other people that help give these pages substance will be protected by Federal statute against unauthorized use for at least 28 years.

To make this copyright stick, though, certain rules had to be followed to the letter. For example, if the simple statement appearing on Page 4 of this issue," . . . copyrighted 1959 by . . .", were omitted, the right to a copyright would be lost forever, and the contents would be fair game for anyone who wanted to reproduce them in any form for any use.

Overlook a simple technicality—lose protection for a valuable property. But those are the rules of the game.

The same holds true for ideas and inventions. One simple misstep, whether through ignorance or negligence, can cost an inventor or a company the rights to a valuable invention. As Del Karger points out in the article beginning on the next page, "some attorneys estimate that as many as 50 per cent of the existing patents can be proven invalid." What a fat target for the calculating business operator who is looking for ways to ride the running board of someone else's ideas!

Competent legal help is the solution to the problem. But often the damage is done long before professional assistance is sought—damage that could have been avoided by knowledge of a few simple, easy-to-apply rules. Mr. Karger's article spells them out.

Don't let a simple legal technicality undermine the worth of a valuable product idea. Know the rules!

Leo F. Spector

ASSOCIATE EDITOR

- Patentable Inventions
- Company Approach
- The Patent Application
- Patent Interference
- Licenses
- File-Wrapper Estoppel
- Outside Inventors
- Design Patents
- Copyrights
- Trademarks
- Service Marks

PATENT

D. W. KARGER
Head
Dept. of Management Engineering
Rensselaer Polytechnic Institute
Troy, N. Y.

IDEAS are not inventions. Neither are patents. Ideas are the prelude to invention and are the tools of the inventor. They are not patentable. Patents are merely the legal documents that describe and claim inventions.

A generally accurate view of a patent is that it is a contract between the government and the inventor. The consideration binding the contract is public disclosure of the invention. In exchange, the government promises to the inventor certain

exclusive rights: 1. The right to manufacture, to use, and to sell the invention so that he may exclude all others from doing any one or all of these. 2. The right to sell his patent. 3. The right to license others to do any or all of these things.

These rights to his invention are the inventor's exclusive property for a period of 17 years. At the end of that time the contract terminates and the public has free access to the invention.

A patent may be invalid or unenforceable, just as any business contract, due to fraud in its inception, a mistake of fact, or failure of consideration. While anyone who obtains a patent has the right to expect it to be valid, the fact is that patents are often proven invalid.

When a businessman is confronted with something that interferes with his interest, he is at liberty to look for "a way around." In the case of adversely held patents, he can legally question its validity (some attorneys estimate that as many as 50 per cent of the existing patents can be proven invalid) or he can seek a way of avoiding the patent by "designing around it" (going to a type of construction that achieves the desired result without infringing or using the invention covered by the patent). Even the U. S. Government at times seeks to evade its own contract—a patent.

ANYONE, citizen or not, and regardless of age or sex, may obtain a U. S. patent on a bona fide invention, no matter where the idea was conceived or developed.

A patent owner may enforce his exclusionary rights by suing infringers through the Federal courts to recover money damages and/or to obtain a court order enjoining and restraining acts of infringement. He may even obtain an injunction to restrain threatened infringement.

The patent owner may "mortgage" his patent by using it as collateral for a loan or rent it by licensing others to make, to use and/or to sell the invention in exchange for payment, cross-licensing, or other legal consideration. He may also bequeath it in his will; otherwise, upon the owner's death, the patent will pass to his heir or successors as part of his personal property. Obviously, the patent

FUNDAMENTALS

A basic guide to what the company and engineer should know about handling ideas, inventions and patents.

owner may, if he wishes, give away his patent during his lifetime or dedicate it to the public.

Co-ownership of a patent carries some far-reaching rights that are sometimes valuable to know. An heir, legatee or other owner of an undivided fractional interest in a patent, in the absence of a limiting agreement, has an unrestricted power to sell or to license the patent, creating in his assignee or licensee the right to make, to use, or to sell the entire invention without the co-owner's consent and without accounting to him for any of the profits or royalties that are received. Except in infringement suits and where no agreement to the contrary exists, the amount of undivided interest owned or assigned is of no importance. Regardless of who he is, the owner of an undivided 10 per cent interest is in as favorable a position as the person owning a 90 per cent interest.

About the author . . .

On the subject of new-product activities, Delmar W. Karger speaks from the authority of first-hand knowledge. His career includes experience in almost every aspect of product development and manufacture. He was formerly manager of new-product development at The Magnavox Co., and also chief plant and industrial engineer. With other companies, he served as consultant on organizational problems, manufacturing engineer, manager of organization and systems, factory manager, and supervisor of co-operative education in a company-wide professional and supervisory training program.

A registered Professional Engineer (Electrical) in Pennsylvania, he holds a B.S. in E.E. from Valparaiso University and an M.S. in General Engineering from the University of Pittsburgh. Author of many magazine articles, papers, and books, he has twice before contributed to MACHINE DESIGN: "New-Product Costs" (September 18, 1958) and "Looking for New-Product Ideas?" (October 30, 1958). His most recent book, *New-Product Development*, is scheduled for release this winter.

Patentable Inventions

INVENTION is generally defined as "something new." The courts and Congress, however, have not defined this term exactly except in a negative way, by establishing some of the things which it is not.

A new item or result is not invention if it is obvious. But obviousness cannot be determined in the abstract sense. It must be evaluated in terms of a particular instance in a particular time period—the time at which the invention was made. The fact that certain phenomena are obvious today, whereas years ago they were not, relates to the time factor.

Substitution of equivalents is not invention. However, if the substitution of an item accomplishes the same result in a different manner or performs a different function, it can be invention.

Checklist of

What are the conditions of patentability? Besides invention, here are ten basic requirements that must be met:

1. The patent applicant must be the original and first inventor and must make an oath (there is one prescribed that he believes himself to be so.)

2. The invention must be useful. It must not be frivolous, contrary to public policy, or inimical to the public welfare. Degree of utility required is not great since such items as "bouncing putty," toy "flying saucers," new species of roses, etc., have been patented. Almost anything falling in this general requirement, providing it meets the other tests, can be patented, except mental processes, mathematical systems, methods of doing business, printed matter, and products of nature such as the chemical elements. However, the process for detecting and/or isolating a chemical element can be covered. Other coverable items by statute are chemical compositions, processes of all kinds, mechanical devices, and electrical circuits.

3. The invention must not have been previously known or used in the U. S., or described in *any* printed publication anywhere in the world prior to its inception. This requirement emphasizes the importance of keeping up with professional and technical published information.
In the restricted legal sense "prior knowledge" means knowledge of a completed and operable device or system. Mere knowledge of the conception of an idea is not enough to prevent issue of a patent to the true "first inventor who makes or completes the invention in operative form."

4. The invention must not have been patented or described in any printed publication anywhere more than one year before the filing date of the patent application. Many foreign countries require that there be no prior publication anywhere before application is filed in those countries.

5. The invention must not have been in public use or on sale in the U. S. by others before the applicant made the invention or by the applicant more than one year prior to filing a U. S. patent application. The moral from this provision is to be prompt in filing. Using experimental models to test the invention is not considered as use in this rule. But use by the government or contractors to the government, in "classified" work is.

A NEW combination of old elements (elements of an electrical circuit, chemicals, materials, etc.) can also be invention if it produces a new result or a desired result in a new manner. Therefore, a combination of known and possibly patented items can still be patentable if the requirement of invention, as viewed by the Patent Office and the courts, is met.

The combination cannot be mere aggregation. The elements or parts must coact or co-operate with each other in producing the final result, either simultaneously and/or successively. The end effect cannot merely be attained by the separate action of each part performing its own separate, individual function.

An illustration of an unpatentable combination is the lead pencil with eraser. The courts[1] held that there is no co-operation or joint action between the pencil and the rubber eraser, that each performs its own function in exactly the same way as before the elements were joined. Hence, the combination cannot be patented.

THE substitution of a different material is not invention unless a new function or result is obtained. For example, the substitution of synthetic for natural rubber as a gasket material has been held as no invention. Had it produced a significantly new result, it would have been invention.

Another negative rule is that changing the size,

[1]References are tabulated at end of article.

Patentability

6. The invention cannot at any time have been abandoned. Ceasing to work on it for a time and then later finishing it would not be considered sufficient diligence in completing the invention to permit patentability.
7. The inventor may not, prior to filing in this country, obtain a patent in a foreign country on any foreign application filed more than 12 months before the U. S. filing date.
8. The invention must not have been described in a U. S. patent. A filed and issued patent is a bar to the granting of a patent to a second applicant. The bar can only be overcome by sworn proof that the second inventor actually completed his invention before the first inventor.
9. The invention cannot be something that is obvious to anyone having ordinary skill in the art.

   Just what constitutes ordinary skill has not clearly been established, especially for our complex technology. As a result, patents may be issued without complete compliance with this requirement. Accordingly, companies engaged in complex research and development work should seek patent protection on all ideas, even those that often appear obvious to the experts and are pronounced as not being patentable.
10. "A person shall be entitled to a patent unless before the applicant's invention thereof the invention was made in this country by another who had not abandoned, suppressed, or concealed it. In determining priority of invention there shall be considered not only the respective dates of conception and reduction to practice of the invention, but also the reasonable diligence of the one who was first to conceive and last to reduce to practice, from a time prior to conception by the other."[2]

The actual date of conception is most difficult to establish since it basically is a personal, mental event. Thus, the inventor should, as quickly as practicable, record and write out a description of the invention, including related drawings. It should then immediately be explained to someone who will understand it and who will sign and date the description, acknowledging the explanation.

Reduction to practice means completion and satisfactory operation of a working model. Where the expense of building such a model is too high, the inventor may make a "constructive reduction to practice." This alternative involves making and filing a patent application and a detailed specification so complete that from it one could build an operable device which would work or perform as described.

Diligence relates to the effort put forth from the time of conception to the reduction to practice or filing of the patent application. Any lack of continuing effort might be in favor of a second inventor working on the same idea.

shape, or speed of one or more elements is not invention unless the result is different or the same result is arrived at through a different or new mode of operation. For example, Edison achieved a patentable invention by reducing the size of an incandescent-lamp filament because it produced a new mode of operation and a new result. In another case, however, the courts held that increasing the vacuum in a high-vacuum tube is not invention since it is merely natural improvement.

In a similar manner, the mere addition or omission of parts is not invention. The added part or parts must co-operate with the remaining parts to produce a new function or result. The omission must also produce a new result, such as is obtained if one part can be made to perform the function of one or more omitted parts which previously were essential to the original invention.

The quality of invention, while essential, does not guarantee patentability. Certain other requirements must also be met. These basic requirements are summarized in *Checklist of Patentability*.

Company Approach

A WELL-PLANNED and executed new-product development program must encompass all of the legal aspects of inventions, including patents. It not only must seek and nurture the development of inventions leading to new products but also must provide for the protection and exploitation of such assets.

A patent is not only a protective device but also a major aid to the exploitation of the development. Up to this point, discussion has covered generally what could be patented. Now, attention will be focused on the procedures involved.

AS has already been both stated and implied, good records are a valuable asset, if not an absolute necessity, in almost any patent prosecution. In many instances it is disastrous not to have them. Most firms employing a significant number of engineers and scientists provide notebooks to record experiments, technical decisions, statements of problems, etc. Recommended practice requires that each page be signed and witnessed.

Notebooks with stitched-in pages do not absolutely require each page to be witnessed. However, the individual-page approach has an important advantage. In a patent action, only selected pages need to be brought into court, rather than the whole notebook which might disclose other data the company desires to retain on a confidential basis.

Patent applications should be developed only by a competent patent attorney. They normally have both engineering and law degrees. A general attorney usually has had little training in practical patent law, copyrights, trademarks, etc., and certainly none in engineering and/or science.

A small firm should establish client relations with a patent attorney, if only to use him initially for advice on how to set up legal and engineering records which will aid the company in protecting developed inventions. Large companies will usually have one or more patent attorneys on their staff and, often, a whole patent department.

Matters on which an attorney should be consulted include the engineer's notebooks mentioned previously, as well as development of a suitable and legally sound employee agreement for assignment of developed inventions to the company. He should also be called on for advice on how to handle both solicited and unsolicited disclosures of possible inventions by "outsiders," for review of company developments to determine whether invention has likely occurred and if patent protection should be sought, for development of a suitable patent or invention-disclosure form, etc.

The new-product development head should align himself closely with the patent attorney or patent department. Each will benefit by the other's activity. The necessity for this close relationship will become more apparent as the legal ramifications of patents, shoprights, copyrights, design vs. utility patents, etc., are discussed here.

IN addition to engineering notebooks, a separate form, ordinarily known as a patent disclosure, can be used to record potential inventions. This disclosure provides not only space for a verbal description of the invention but also for required drawings, the inventor's comments on known prior or related "art" (knowledge), and the witnesses' oaths and signatures.

Usually provision is made for two people to sign. The inventor describes his "brain child" to witnesses who should have the technical knowledge and

ability to understand his explanation so that they can swear to the explanations and make an attestation similar to that shown in *Typical Witness Oath.* The witness form is usually of a nature to permit easy reproduction.

Where each page of the engineer's notebook is to be signed, a separate patent disclosure form is not needed if the individual notebook pages are reproducible and generally removable from the binder, and space is provided for supplementary information aimed at the patent attorney who has only limited technical background. Most firms, however, use the separate form for obvious reasons.

This witness provision is often misunderstood. A common misconception is that a person secures protection for his invention by sending a registered letter to himself in which the invention is described and his signature is notarized. Such a letter is generally meaningless since the inventor hasn't established proof, by explanation to witnesses, of his real understanding of the invention. It can only help in substantiating the date of inception of the claimed invention.

The previous discussion implies that inventions made on the job are company property. The courts have generally upheld this view. But to eliminate problems and difficulties, most companies require at least their technical and/or other creative personnel to sign agreements to assign their inventions to the company and also to protect the company's trade secrets. However, an invention cannot be assigned until it can be identified. This qualification is another legal technicality requiring the services of an attorney.

The actual assignment of an invention must be in writing and must identify the invention unmistakably. Identification can be made by a description of the invention or by reference to the serial number and the filing date of the patent application.

If the assignment is of an issued patent, it must identify the patent number. Provision is made for recording assignments in the U. S. Patent Office in a manner similar to that for recording deeds to real property in the county clerk's office.

RECOGNITION of patentable invention is a complex matter. All chief engineers and project engineers should at least be given some rudimentary training regarding inventions that can and should be patented. Necessary basic information should not only be in written form but should also be explained to them by the patent attorney.

If invention is not recognized it will be lost to the company. This problem "points up" the need for having people who are trained to recognize invention review engineering notebooks. People without proper training tend to take the "easy way out," claiming an invention is old art and can't be patented or that any patent obtained would be too weak to be worth the effort.

Most large companies have a patent committee which usually consists of the chief engineers, the head patent attorney, and the manager of new product development. In some companies the sales manager and factory manager are added to this committee. The committee normally reviews disclosures of inventions and decides what action should be taken concerning them; that is, should a patent application be filed or not, should an initial search of prior art be made to determine related patented inventions, etc.? The idea is fine, but the men must have the training mentioned before if the committee is to be effective.

A new term has been mentioned: Initial or novelty search. No patent attorney can ordinarily, much less always, make a quick examination of a product or a process to determine whether or not it is a new invention and therefore patentable. On most questionable instances, the patent attorney makes what is known as a novelty search of prior art in the Patent Office to find out whether the invention is in fact probably new and can, therefore, be patented. This search may require anywhere from a few hours to days, depending upon the extent of the prior art. Also, after making the search, the attorney must often study and analyze prior or related patents found in the search to determine whether the inventor's proposal appears sufficiently different and clear cut to be patentable.

Sometimes, because of the diverse and broad art apparently existing or because of other factors, the attorney may decide to draw up a patent application and to start prosecution of the patent. Final decision will then be based on the first action received from the Patent Office on the patent application. Making the proper decision at this point requires experience and sound judgment.

The actual patent application must describe the invention clearly. The person writing out the patent application needs to understand the word usage associated with patent applications and to take full advantage of it. Here again is the need for the specialist—a patent attorney.

Companies frequently manufacture and sell a product before a patent is obtained because of the long processing time required in the U. S. patent department. In such situations, they may attempt to at least partially protect their interests by marking the product with "patent pending" or "patent

applied for." Actually, a patent applicant has no rights under the patent statute until the patent is issued, and then the rights are not retroactive. Nevertheless, this practice has served as an effective deterrent to competition. However, the law counts it a punishable misdemeanor to so mark a product if a patent is not actually in process by the Patent Office.

At this point, two helpful publications should be mentioned. Both are available from Superintendent of Documents, Government Printing Office, Washington 25, D. C. The first is a compilation of patent laws. The other is a roster of attorneys and agents registered to practice before the U. S. Patent Office. These and other useful publications are listed, with prices, in *Government Publications*. In addition, fees for the different services and operations of the Patent Office are listed in *Patent Office Fees*.

The Patent Application

THE claims in a patent application must be carefully worded because they are the only basis of patent protection. They should be stated in as broad terms as possible so that it will be difficult to impossible for someone else to design around the patent.

If even one part of each claim can be eliminated, another person may be able to produce a comparable device without infringement of the patent.

In the usual routine of handling patent applications, the Patent Office reviews the application, cites known prior art by referencing prior or related patents, and indicates which of any of the claims they will allow. This initial operation of the Patent Office is generally known as "first action." The patent attorney and the inventor must then review the material supplied by the Patent Office, make corrections and/or additions, rephrase the claims where required, and resubmit the application. A period of 6 months is allowed the inventor to reply to this first action.

If the required revisions are of such an extent that practically a new application need be made,

Government Publications

Official Gazette of the United States Patent Office:	
Annual subscription, domestic	$30.00
Annual subscription, foreign	38.00
Single numbers	.75
Annual Index relating to patents	varies
Decisions of the Commissioner of Patents	varies
Manual of Classification of Patents	12.00
Foreign	15.00
Manual of Patent Examining Procedure	6.25
Foreign	7.50
Rules of Practice of the United States Patent Office in Patent Cases	.50
Rules of Practice in Trade-Mark Cases, with forms and statutes	.40
Patent Laws	.25
Roster of Attorneys and Agents Registered to Practice before the United States Patent Office	1.00
Guide for Patent Draftsmen	.15

Patent Office Fees

Filing fee. On filing each original application for a patent having 20 claims or less, except in design cases	$30.00
For each additional claim over 20	1.00
Final fee. On issuing each original patent having 20 claims or less, except in design cases	30.00
For each additional claim over 20	1.00
Filing fee, designs:	
For term of 3 years and 6 months	10.00
For term of 7 years	15.00
For term of 14 years	30.00
Filing fee, reissues. On every application for the reissue of a patent	30.00
For each claim which is in excess of 20 as well as in excess of the number of claims in the original patent	1.00
On filing each petition for the revival of an abandoned application for patent	10.00
On filing each petition for the delayed payment of the final fee	10.00
On an appeal for the first time from the primary examiner to the Board of Appeals	25.00
On filing each disclaimer	10.00
For certification of copies of records, etc., in any case, in addition to the cost of copy certified	1.00
For typewritten manuscript copies of records, for every 100 words or fraction thereof	.10
For photostat copies or records or printed material, per sheet	.30
For photoprints of drawings, for each sheet of drawing	.30
For uncertified printed copies of the specifications and accompanying drawings of patents, except design patents, if in print, each	.25
For uncertified printed copies of design patents, if in print	.10
For recording every assignment, agreement, or other paper, not exceeding six pages	3.00
For each additional patent or application included or involved in one writing, where more than one is so included or involved additional	.50
For each additional two pages or less	1.00
For abstracts of title to each patent or application, minimum charge	3.00
For translations, made only of references cited in applications or of papers filed in the Office, for every 100 words or fraction thereof	1.25
For making drawings, when they can be made by the Patent Office, the cost of making the same; minimum charge per sheet	15.00
For correcting drawings, the cost of making the correction; minimum charge	1.00
For the mounting of unmounted drawings and photoprints received with patent applications, provided they are of approved permanency	1.00
For lists of United States patents classified in a subclass, made to order, per sheet (containing 100 patent numbers or less)	.20
For certificate of correction of applicant's mistake	10.00

the revised application can be filed as a "continuation-in-part." If such a continuing application is filed within the 6-month statutory period, it is accorded the benefit of the inventor's original filing date, at least with respect to the subject matter disclosed and claimed in the original application. In the event that a continuation-in-part application is filed, the attorney normally makes a formal abandonment of the original application after receipt of the official filing receipt covering the new application.

Many Patent Office actions are possible before the actual patent is received.

A PATENT claim may be avoided or designed around by building a product, or by using a process, which omits at least one element of the claim. However, infringement cannot be avoided by merely adding something to the combination of a prior patent claim. Also, omission cannot be achieved by merely substituting an equivalent element.

For a patent to be infringed, every element of one claim must be included in the so-called infringing structure. Long and detailed claims are said to have a narrow scope since they tend to be easily avoided by omitting one of the claim elements.

The question of equivalents is a troublesome problem. The courts have ruled that an equivalent not only must perform the same function, but it must do so in the same mode of operation. Otherwise, it does not come within the patent claim.

The general rule is that one cannot employ a mechanical equivalent whose mode of operation is the same as that of the patent or, in chemical cases, that one cannot substitute a chemical which will perform the same function as the chemical cited in the patent claim. For example, the court ruled that cellulose acetate could not be substituted for nitro cellulose to circumvent a plastic wood patent, since the substitution was an obvious equivalent.

The cost of prosecuting an infringement suit is so expensive that it normally is uneconomical unless substantial returns in the way of damages are readily foreseeable. Infringement suits can easily cost $25,000 to $50,000.

As a general rule, accidental, unintentional, and transitory production of an invention does not ordinarily constitute infringement. A case of transitory production can occur in a continuous manufacturing process where at one stage in the manufacture of an end product the material in process incidentally passes through a momentary state or condition which falls within the terms of someone's patent claim. However, one cannot avail himself of the advantages of a patented invention merely by performing additional operations to modify the end product.

Patent Interference

PATENT interference basically is a contest in the patent office between two or more inventors who have disclosed and claimed the same invention. The purpose of the contest is to decide who was the first to make the invention. The first inventor will obviously be awarded the patent since the same invention cannot be covered by two different patents.

Patent interference proceedings usually are started by the patent office examiner (the patent-office official handling the inventor's application). A notice is sent to the applicant, advising him that he should amend his application by copying a claim suggested by the examiner. This action is taken when it is discovered that two applications have been filed in the office by two or more inventors generally claiming the same invention.

The reason for suggesting an exact claim to be copied is that no two inventors and/or attorneys will write their applications in exactly the same manner and claim exactly the same thing. Overlapping claims would result if both of them were granted patents. However, this situation sometimes occurs when the examiners do not discover the overlapping claims.

If the suggested claim is not copied within a prescribed time (usually 30 days), the inventor is forever barred from asserting that claim or from arguing that other claims in his application should be interpreted to cover the subject matter in the suggested claim. To avoid this condition, the inventor would be well advised to copy the suggested claims for interference purposes.

Another way to start interference proceedings is to voluntarily copy a claim from an issued patent. However, when this is done the applicant should identify the patent from which the claim is copied and state that it is copied for interference purposes.

This identification is important since different examiners, handling similar subject matter, may not realize that conflicting claims are in the Patent Office. Hence, a patent may be issued to one inventor while the other case is still in process.

Sometimes both inventors will have an issued patent. Here, the Patent Office will not and cannot declare an interference because they have no jurisdiction over patents after they are issued. One of the patentees must provoke interference proceedings by filing an application for a reissue patent. This action must take place within 1 year of the issue date of the other patent. Ordinarily the aggressive party here is the patentee with the later filing date since if two or more patents claim the same invention, the patent with the earliest filing date dominates those filed later.

SINCE the sole issue in an interference is one of fact—that is, identifying the first inventor—the records associated with the complete progress of the invention's development are particularly important. To win requires a preponderance of legal proof and in some cases, proof beyond all reasonable doubt. Documentary records and testimony of witnesses are essential. The elements of proof required to establish priority and to win an interference are: 1. Conception. 2. Reduction to practice. 3. Diligence.

Many interference proceedings have been lost because corroboration by witnesses could not be obtained. Failure to establish proof of any one of the three elements can be fatal to the interference proceeding.

Proof of diligence does not necessarily require that the inventor spend all of his time in reducing the invention to practice. He may have to earn his living by other work and can only devote spare time to completing the invention. This fact will be recognized as due diligence. Since the parties concerned in an interference proceeding may, by mutual consent, examine each other's proof and data, the outcome often can be anticipated. The parties may then settle the issue by a concession of priority with or without an exchange of license.

Settlement of an interference should always be based on fact. Otherwise, if the dates are quite close and the priority is questionable, even though the contestants settle the issue between themselves, the actual validity of the patent which issues with the contested claim may subsequently be attacked by others who desire to use the patent on the grounds that a mistake was made by the parties in their determination of priority.

Where conflicting patents are involved, the issue can also be settled by a civil action which may be brought by either patentee or by any person interested in working the invention claimed by either patent. A suit in equity is instituted against the owner of the interfering patent. It may be commenced in the U. S. District Court or in the District of Columbia.

The losing party to a Patent Office interference action may appeal the case to either the Court of Customs and Patent Appeals or the U. S. District Court for the District of Columbia. Ordinarily, the decision of the Court of Customs and Patent Appeals cannot be appealed to a higher court. However, further appeal may be taken from the Federal District Court to the Circuit Court of Appeals, and from there to the U: S. Supreme Court for a final review.

Typical Witness Oath

The invention was first explained to me by the above identified inventor(s)

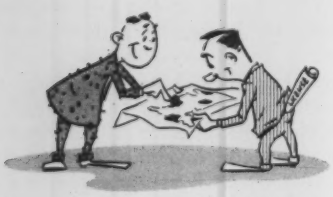
on_____, 19__.

_____ _____

Signature of Witness Date of Signature

Licenses

A PATENT owner may license anyone to use his patent. The license may be either exclusive or nonexclusive. An exclusive license is an agreement not to authorize or license anyone else under the patent. A truly exclusive license deprives the patent owner of his rights to manufacture, to use, and to sell, and gives the sole rights to the licensee. A truly nonexclusive license does not contain any reservations by the patent owner or restrictions on him which would prevent him from licensing others.



In actual practice, most of the licenses existing in industry are neither truly exclusive nor nonexclusive. That is, they are restrictive or only partially restrictive as to the basic rights to manufacture, to use, and to sell. In fact, they are often written so as to be effective only in certain specified territories. The variations are broad.

The nonexclusive license is the more common form. Generally, such nonexclusive licenses include a "favored nation" clause which assures the licensee that the patent owner will not grant a license to anyone else for less consideration; that is, for a lower royalty rate or fee.

A LICENSE may be either oral or written. It can even be implied from the actions of the parties. Practical considerations, however, dictate that where a license is intended it should be clearly expressed in writing and, if it is exclusive, properly recorded. Nonexclusive licenses cannot be recorded in the Patent Office.

An implied license arises either by statute, by law, or by the legal doctrine of estoppel. The most common implied license is the one granted to use a patented product when it is purchased from the patent owner or from a licensed manufacturer.

Another form of implied license occurs when a patent owner sells an unpatented article or part to a customer in the knowledge that the article is to be used in a process or device covered by the owner's patents. Service parts are a simple example of this type of implied license. The purchaser of a patented machine has an implied license to use the machine and to make the normal repairs necessary to keep the machine in operation.

In any event, when the patent owner leads someone to believe that he has a right to operate under the patent or that he may proceed without fear of action for infringement, and the party relies on this inducement, the patent owner will thereafter be estopped from enforcing his patent against this party.

Except for limitations set forth in the antitrust law, a patent owner in the U. S. does not need to license anyone; neither does he need to practice the invention in any manner whatsoever. In many foreign countries, however, patents must be directly "worked" by the patent owner or a licensee, or else they become subject to compulsory licensing to anyone.

A LICENSE may be restricted as to the territory in which the licensee may operate; to certain specified uses; to a term of years less than the life of the patent; as to the quantity of goods that may be manufactured, sold, or used; as to the sale of patented goods at a fixed price; etc.

A license granted to a parent corporation does not include a license to a subsidiary unless this privilege is expressly stated in the license agreement. Most license agreements also cover the question as to whether sublicenses can be granted under the patent; that is, can the licensee license others to operate under the patent.

Licenses granted in the chemical industry, as well as in others, often cover the right to make, to use, or to sell a specified product or to operate a designated process without reference to any specific patents. In these situations, the licensee acquires the right to use the subject matter in any or all of the patents of the licensor relating to the licensed products or processes.

Subject-matter licenses can be interpreted to include further improvement patents that the licensor may obtain during the life of the agreement. License agreements also frequently include a condition requiring the licensee to disclose to the licensor any improvements made in the product or process and, if improvement patents are obtained, to assign and/or to cross-license such patents to the licensor.

Royalty rates for patent licenses normally range from 1 to 5 per cent of the selling price. However, the royalty can be established in other ways, such as a fixed charge per piece made, used, and/or sold. If a percentage arrangement is used to establish the royalty fee, it is often based either on the manufactured cost or selling price of the product. Packing costs may or may not be included in the selling price.

There is no limitation as to what an inventor may charge as his fee for licensing someone to operate under his patents. It is purely and simply a question

of economics. When he sets his fee too high, his income can be nil or very low if he forces the licensee to "charge more than the market will bear" because of the need to recover the royalty cost.

Up to this point, licenses have been considered primarily in terms of existing patents. However, just as an idea can often be sold to a company before a patent has been obtained, a license to manufacture and/or to sell a product can be negotiated before a patent is obtained. The life of such licenses is often contingent upon the licensor obtaining a patent and, sometimes, the royalty varies with the patent situation.

Among the benefits that can be sold or licensed is access to engineering and manufacturing skills related to the manufacture of the product. This provision is often included in licenses based upon patented ideas.

File-Wrapper Estoppel

SOMETIMES, a patent claim may be subject to restricted interpretation. This condition occurs if, during the prosecution of the patent application, the inventor or his attorney has to define the meaning of certain elements in a claim or claims to the point that only a restricted interpretation could result. Such action, or argument, can create what is known as "file wrapper estoppel," which means that a claim may appear on its face to be infringed but file wrapper estoppel compels a finding of no infringement.

The entire history of the patent application is available to the public after the patent issues. Anyone who wishes to examine the file of an issued patent can do so in the public search room of the Patent Office or he can purchase from the Patent Office a certified and photostatic copy of the complete file wrapper. An abstract of the file wrapper can also be obtained from public stenographers in the Patent Office.

Outside Inventors

IF an inventor or presumed inventor discloses his secret in confidence to another, the person receiving the confidential information assumes an obligation neither to disclose the secret to anyone nor to use it for his own benefit without the permission of the inventor. This obligation remains even if the item disclosed is not valuable or patentable, or if it is patented by the inventor after the disclosure.

The courts have steadfastly upheld this viewpoint. Consequently, manufacturers should be wary of accepting any confidential disclosures. There are cases on record where the disclosed idea was from an expired patent, which is actually in the public domain, and the courts in different cases have held both for and against the persons disclosing the idea.

Because of the possibility of being prohibited from using unpatentable and widely known material or processes through a supposedly confidential disclosure, most companies have adopted the policy of refusing to receive any such disclosures. Many others will only consider inventions from outsiders after a patent application has been filed and with the understanding that the inventor's right to recover for use will be solely limited to the subject of any valid patent claims. The most common practice is to require the inventor, if he proposes to submit an invention disclosure, to first submit an agreement limiting the company's liability for their consideration of the disclosure.

Unsolicited disclosures are from time to time received by nearly all manufacturers. The receipt of such material poses a problem, especially if it is read by any of the company's engineers or technical personnel. Many companies issue standing instructions to their incoming-mail department to route all such correspondence to a designated individual. This person is usually a nontechnical employee who is instructed to seal the disclosure and to place it in the company vault. Then, as a general rule, a form letter is sent to the person who submitted the disclosure, asking him to sign a disclosure statement. Obviously, this disclosure statement must be carefully worded.

Design Patents

SO FAR, this discussion has dealt mainly with patents of the general type known as mechanical, or utility, patents. Those with very broad claims are sometimes referred to as basic patents.

The patent law also provides for the issuance of design patents for certain types of new and/or ornamental designs. The theory of this section of the patent law is that a unique and aesthetically pleasing design of an article may be an important factor in its commercial success and should be accorded some protection from copying. Design patents only disclose and cover the exterior appearance of an article, not its internal structure, workings, functions, or functioning. Because of their limited scope, they are generally less valuable than mechanical or utility patents.

Design patents can be obtained for periods of 3½, 7, or 14 years, depending upon the fee paid by the applicant and the time period he requests or elects to apply for. Applications for design patents are examined for novelty and ornamentality, but not for utility. It is only possible to cover one part in a design patent. If two or more parts are involved, separate design patents must be obtained for each part. For example, two design patents must be obtained to cover a desk pen set which includes a holder and a pen which is separable from the holder.

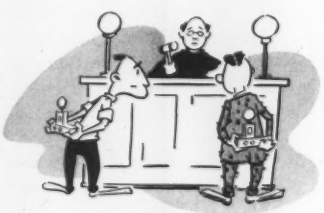
Design patents are normally used to protect items such as chinaware, wallpaper patterns, radio and television cabinets; bathroom fixtures, etc. They also can be used to cover parts such as machine screws. Here, one normally can, and should, secure a utility patent, unless only an ornamental design is involved. Yet, as a result of convincing arguments presented by patent attorneys to Patent Office officials, more than just ornamental structures have been covered in actual practice. When an item can be covered by either utility patent or a design patent, the utility-patent protection is usually advisable, if for no other reason than that the utility patent is issued for a longer period.

EVEN without a design patent, the law provides, in some instances, protection against copying of products by competitors. Most of this protection stems from the sweeping monopoly granted by the law of unfair competition. Unfortunately, the layman is faced with a difficult task in trying to interpret or predict just what is protected. Sometimes, a "Chinese copy" is legal whereas in another case the mere similarity in appearance of a competitor's product may be ruled illegal. Some of this seeming confusion may be clarified by the examples which follow. Although all concern cases where no design patents, copyrights, or registered trademarks were in existence, the concepts involved are basic.

For many years a Swiss clock manufacturer had marketed in the United States a spring-driven clock unit of very unusual and distinctive exterior design which was kept wound by temperature changes. An American manufacturer then attempted to market a clock which was of the same general shape and size but was driven by an electric clock motor. It also was much lower in price.

In spite of no utility or design patent coverage in this country, the court ruled that a secondary meaning, other than mere aesthetic effect, was attached to the Swiss clock. It further said: "The actionable harm in a secondary meaning case may result either from the likelihood (a) of loss of customers, or (b) loss of reputation, or (c) of both. Such loss can result from the customers' belief that the competing article derives from the same source as that of the party complaining and it matters not whether the customers know just who is the source."[3] The result was the sustaining of an injunction against the competitor on the basis of unfair competition and piracy of design.

Another similar case, seeking an injunction against a second manufacturer, involved the use of a plastic material to make kitchen canisters. Here, the court denied the existence of a secondary meaning attached to the duplication of product.



"The test of secondary meaning is, of course, 'likelihood of confusion' and not actual confusion. But the confusion does not stem merely from the similarity or even identity of the questioned products with that of the first comer. It must be the confusion of the manufacture, and relates to that which attaches to the personality of the manufacturer. The first maker of plastic canisters in this appealing style may have created a public desire for one of two things, (1) plastic canisters made by him alone above all other plastic canister makes, or (2) plastic canisters in a particular form regardless of who made them. The sweeping monopoly granted by the law of unfair competition extends only to the first of these conditions."[4]

In the previous Swiss-clock case, which involved

confusion of manufacture, the first manufacturer had built up an apparent demand for his particular style of product. In the plastic-canister case, the built-up desire apparently was limited to the general shape, not the first company's particular product.

Related advertising can often substantiate the claims of a built-up desire for a particular product. A fastener manufacturing company had for years widely advertised its product as "the nuts with the red color." This phrase referred to the red fibre or plastic insert in the top of the nut. When suit was brought against a second manufacturer who marketed a copy also having a red insert, the first company won its case. The court stated[5] that the test should be whether or not the public is likely to be deceived. They also declared that the courts should not be so feeble as to be unable to prevent the good will of a manufacturer, built up at great expense, to be whittled away.

A somewhat similar situation involving a watch company was also backed up by the courts. This company for years had marketed its watches under a proper name. When another watch company, located in a city of the same name, attempted to use this name on their watches, suit was brought.

In answer to the second company's defense that they certainly should be allowed to identify the city of manufacture, the court said: "It is true that a man cannot appropriate a geographical name, but neither can he a color or any part of the English language or even a proper name to the exclusion of others whose names are like his. Yet color in connection with sufficiently complex combination of other things may be recognized as saying so substantially that the competitor's goods are the first manufacturer's as to pass the injunction line. So, although the first manufacturer has no copyright on the dictionary or any part of it, he may exclude a competitor from a part of the free field of the English language, even the mere use of generic words, unqualified and unexplained, when they would mislead the other manufacturer's customers to another shop. Whatever might have been the doubts some years ago, we think that it is now pretty well settled that this manufacturer merely on the strength of having been the first in the field, may put later comers to the trouble of taking such reasonable precautions as are commercially practical to prevent other lawful names and advertisements from deceitfully appropriating this manufacturer's customs."[6]

Somewhat related to the case involving plastic kitchen canisters was one concerning similar wrench designs of two manufacturers. One design had been on the market for three years when the other was introduced. Both wrenches were of the same style but the second manufacturer displayed a different name in the web of the handle.

In the decision denying the first manufacturer an injunction; the court stated "It is an absolute condition to any relief whatever that a producer in such cases show that the appearance of his wares has in fact come to mean that some particular person—the producer may not be individually known—makes them and that the public cares who does make them, and not merely for their appearance and structure. . . . The competitor has as much right to copy the nonfunctional features of the article (design, color, dress) as any others so long as they have not become associated with the other party as the manufacturer or the source. The critical question of fact at the onset always is whether the public is moved in any degree because of its source and what are the features by which it distinguishes that source."[7] The fact that a name appeared very plainly on the handle probably was of much significance in this case.

The final illustrative example involves a coffee mill of characteristic shape and appearance. It had been manufactured by one firm for over a quarter century. During this time, the company had built up an enviable reputation and had captured a large portion of the market. Subsequently, a competitor copied the design, shape and color and offered such mills to the trade. Suit was brought and an injunction was granted.

The court in its ruling said: "It is elementary law that when the simulation of well known and distinctive shapes is so close, the courts will assume that the competitors intended the result they have accomplished and will find an intent to appropriate the trade of the other competitor, even though in their instructions to their own salesmen they may caution against oral misrepresentations as to the manufacture of the goods."[8]

The court also indicated that purchasers had been deceived by the "Chinese copy" and that there was misrepresentation, no matter whether it was by word of mouth or, more subtly, by simulating the collocation of details of appearance which the consuming public had come to recognize in the product of the first manufacturer.

The concepts presented here are based on American practices. However, the American convention for identifying the different types of patents is not universally followed in other countries. In Japan, for example, a utility patent actually covers minor inventions that are not deemed worthy of being accorded the status of a senior or more important invention. To a degree, they also cover the kind of items included in a U. S. design patent. Germany has a similar convention.

Copyrights

THE designs of certain articles may be protected by copyright registration, rather than a patent, if they are classified as works of art. Such items include artistic jewelry, enameled glassware, etc. Copyright registrations offer some advantages since they provide protection for a longer period, namely 28 years, and may be renewed for a like period. Also, the work of art need not be novel or inventive although it must be original with the artist or author who claimed the copyright.

There are two basic kinds of copyright: Common law and statutory. Common-law copyright is a fundamental right which stems from the common law and will be upheld by the courts even without a certificate of copyright registration. It covers the results of an individual's personal efforts and intellectual labor. For example, everyone has an inherent common-law copyright on his private correspondence, speeches, etc. However, if such writings or speeches are published without restriction, then the common-law right is lost. Statutory copyright has the same constitutional origin as the patent laws. Responsibility for the registration of copyrights is placed in the Library of Congress. The register of copyrights is empowered to issue certificates of copyright registration to anyone who complies with the prescribed regulations. The application for copyright can be made by the original author, his legal representative, or the company that publishes the work. There is no examination of the work for novelty or originality. However, the copyright is only valid if the work is original.

The statutory notice—"COPYRIGHT, (year), By (name of author)"—must appear on the book or other material at the time it is printed and distributed. In fact, it must so appear before registration. Without this action printed and distributed material becomes dedicated to the public.

Trademarks and Service Marks

TRADEMARK-LAW philosophy is based on protection of the public, whereas the patent law was created to protect the inventor and/or manufacturer. Since the "public interest" is involved in legal cases dealing with trademarks, the courts tend to be much stricter in their rulings on trademark infringement.

The trademark is a well-established device for identification of goods. It is indispensable in sales promotion and advertising and offers many benefits. Registered trademarks never expire although they may be lost through nonuse or through misuse. Here, again, an attorney should be called in to advise the company on how to handle trademarks.

The right to trademark protection is fundamental under common law and/or is acquired by priority of adoption in use rather than by registration. Congress has, however, passed a number of federal laws which provide for registration in the U. S. Patent Office of trademarks that are used in interstate or foreign commerce. Generally, the best trademarks from a legal viewpoint are those that are coined or made up as a fanciful combination of characters or symbols and convey no primary or generic meaning. However, this ideal is in direct contradiction to the type of trademark ordinarily preferred by advertising managers.

A trademark or brand name has to be used before any rights arise. In fact, before registration can be effected, the mark has to be used on the product itself or on its container.

Occasionally one manufacturer may wish to license another to use his trademark. This transfer of rights is difficult to accomplish without risking loss or abandonment of all rights in the mark.

SERVICE marks are similar to trademarks and are used to identify services rendered. They have the same purpose as trademarks and are acquired and protected in the same manner. They normally appear on literature, brochures, stationery, advertisements, etc., since there is normally no physical product involved and service is the thing offered.

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2. Section 102(g), revised patent statute enacted July 19, 1952.
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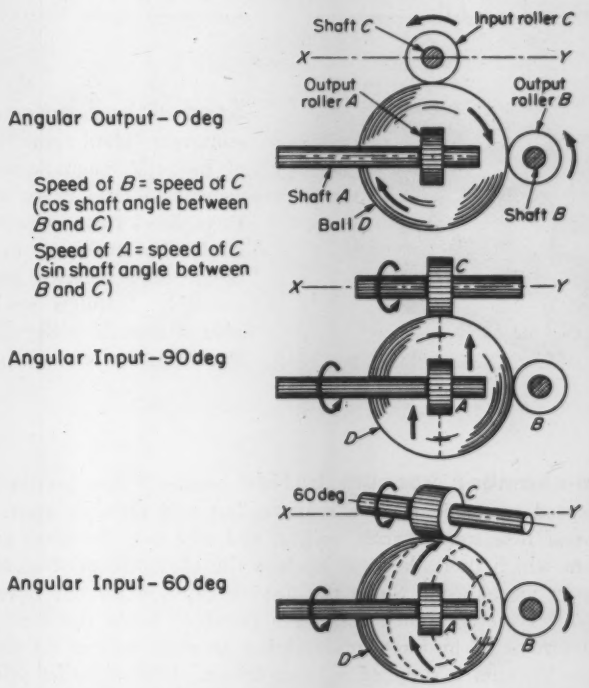
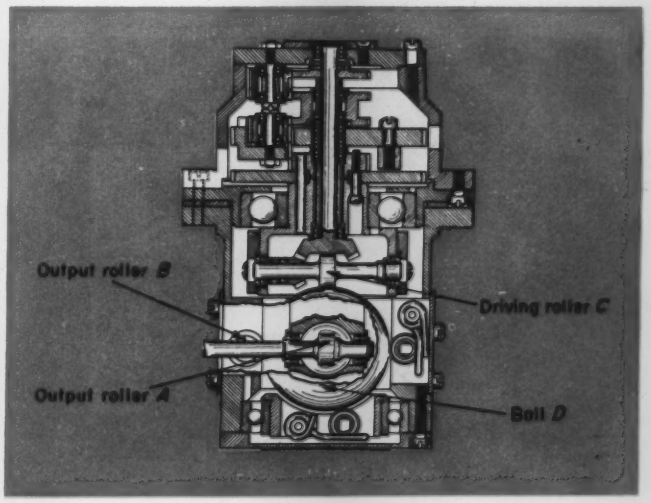
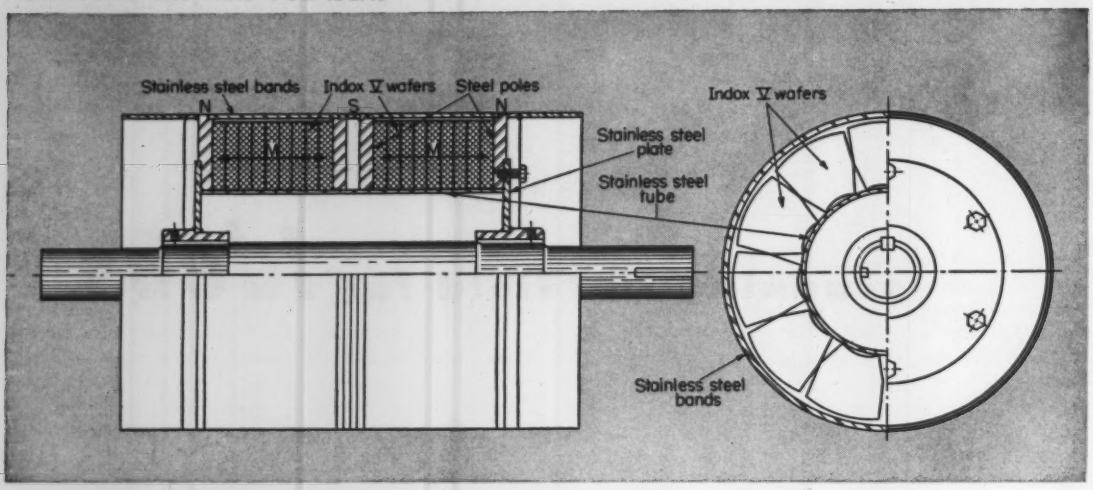
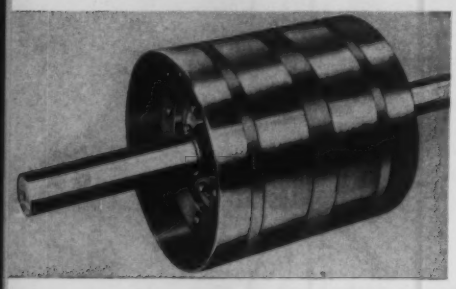
scanning the field for *ideas*

Ball function generator resolves speed and angular position of input shaft into accurate trigonometric relationships for instantaneous calculations. Three equal-sized rollers, mounted on shafts, are positioned to contact a 1-in. diameter steel ball, *D*, at three points. Points of contact lie in three right-angle planes. Two of the shafts, *A* and *B*, serve as function outputs and the third shaft, *C*, serves as an input. A drift meter controls angle of shaft *C*. Speed of *C* is controlled by speed indicator. Shaft *B* reflects the cosine function of the angle formed between shafts *B* and *C*, while shaft *A* reflects the sine function of the same angle. These angle functions vary continuously as angular and speed inputs change. The output functions are fed to a computer which performs position computations. Ball principle employed in a Ball Resolver developed by Aviation Electric Ltd., Montreal, Canada.


Angular Output – 0 deg
Speed of B = speed of C (cos shaft angle between B and C)
Speed of A = speed of C (sin shaft angle between B and C)
Angular Input – 90 deg
Angular Input – 60 deg
Shaft C
Input roller C
Output roller A
Output roller B
Shaft A
Ball D
Shaft B
60 deg

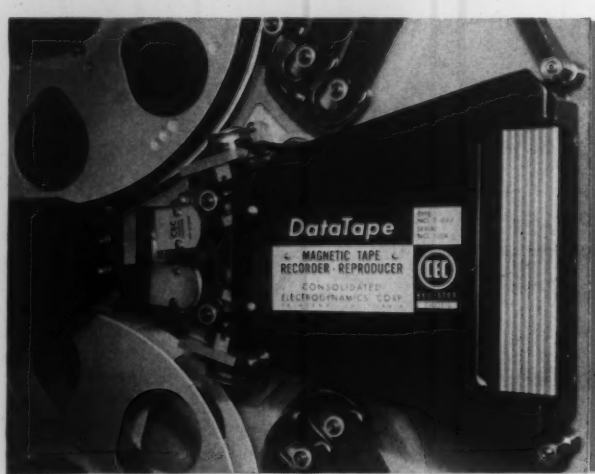


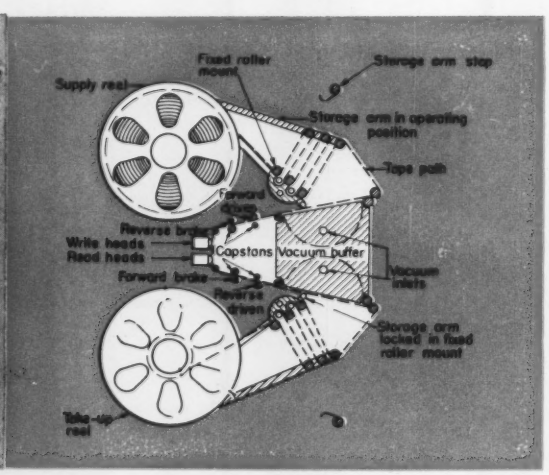


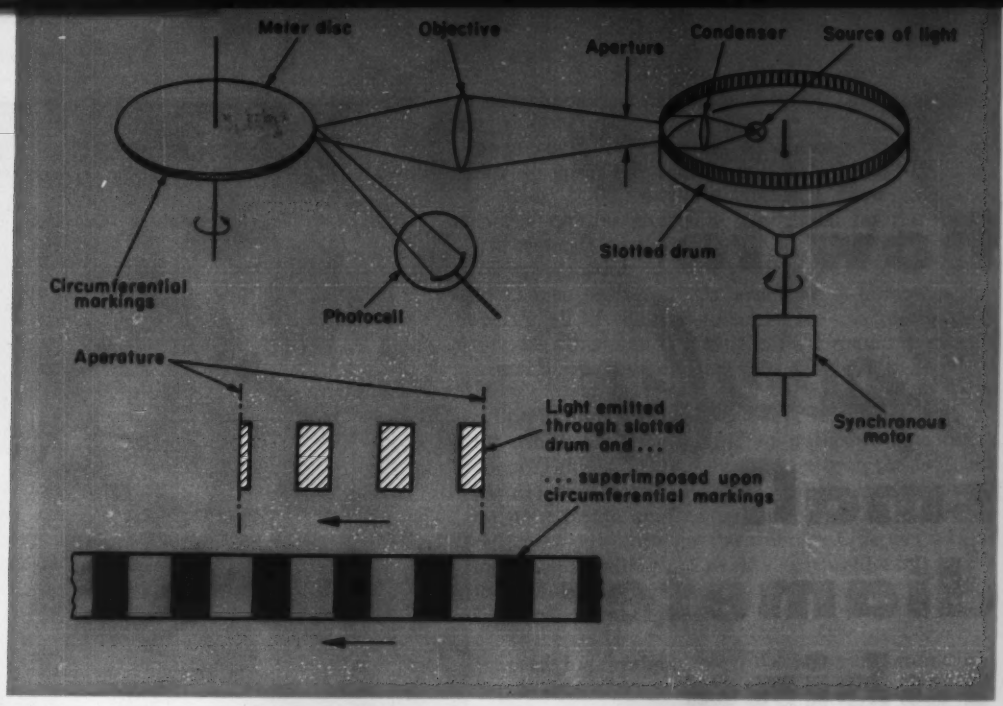


Sandwiched magnetic wafers form radial poles which eliminate "blind spots" in a permanent magnet pulley. Thin wafers of Indox V magnetic material, cemented in place with epoxy resin cement to form rings, are magnetized through the thickness of the rings. Steel rings, adjacent to the wafers, are welded to a stainless-steel tube and serve as magnetic poles. The two inside poles are of the same polarity, resulting in a three pole, two-pocket magnetic assembly. Stainless steel bands are welded between the poles to give a smooth pulley face. Design developed by Stearns Magnetic Products, Div. of Indiana Steel Products Co., Milwaukee, Wis.

Twin-chamber vacuum buffer creates a low inertia point from which high-speed magnetic tapes can get a fast and accurate start. To overcome the inertia of tape storage arms, rollers, and reel, two chambers are supplied with a vacuum which pulls the tape up into the chambers prior to starting of the tape transport mechanism. Since the driving capstans do not have to overcome this mechanical inertia, quick starts are possible. Once the tape is in motion, the vacuum remains in force, maintaining an even tension on the tape during operation. Vacuum is supplied by a centrifugal blower. Buffer principle employed in Type 5-682 Recorder/Reproducer developed by DataTape Div., Consolidated Electrodynamics Corp., Pasadena, Calif.







Slotted drum "measures" angular velocity of electric meter disc by superimposing light rays on disc circumference. A photoelectric scanning unit projects and superimposes light, emitted through a slotted drum, upon circumferential markings on the meter disc. Differences in angular velocities between disc and drum modulate the frequency of the light pulses. The pulse frequency, reflected off the disc and picked up by a photocell, is a measure of disc angular velocity. For meter calibration, two scanning units are used to compare a standard meter with meter being adjusted. Each pulse from the photocell, is amplified into a rectangular voltage of nearly constant amplitude. These voltages from each unit are then transformed into pulse sequences whose frequencies correspond to the modulated frequencies of the light rays. Proportional to angular difference between meter discs, phase shift between pulse sequences controls deflecting coils in standard television tube, which improves visibility and avoids circular readout. The minute angular velocity differences indicated are made to approach zero in calibrating the meter. Scanning principle used in meter calibrating equipment developed by Allgemeine Elektricitaets-Gesellschaft, Berlin, Germany.

how to *specify* small diameter tubing

HARRY W. POOLE
Director of Quality Control
Superior Tube Co.
Norristown, Pa.

PERHAPS none of the forms in which metal is usually supplied for fabrication is subject to more misconceptions and errors in specification than tubing. This is because tubing is "four-dimensional." Variables are OD, ID, wall thickness, and length, which, in turn, give rise to other variables such as condition of the bore, ovality, eccentricity, and variations in wall thickness. Only in very rare applications is more than one dimension critical.

If tolerances other than standard are required, designers should specify:

1. Which dimension (OD, ID, or wall) is important and why.
2. Exactly how the tubing will be used and reasons for the performance requirements.
3. How dimensions of the tubing will be measured and properties tested so that the supplier can correlate his own methods.

With this information, the supplier can recommend specification changes which may cut costs and/or improve quality.

Selecting Tubing Material: Relative costs of material cannot be judged on the basis of initial cost alone. Frequently, production costs or the life of the material will outweigh savings in initial costs. However, if it is subject to a corrosive environment it must be plated, and the cost of plating may make it more expensive than the stainless steel. And while titanium tubing is one of the most expensive, its exceptional corrosion resistance to certain chemicals gives it a life expectancy that may actually make it the cheapest. Of course, the application may be such that only one material will serve satisfactorily.

Specifying Wall Thickness: Walls that are too thin are sometimes specified in the mistaken belief that the lighter wall results in substantial savings. In the manufacture of tubing, however, most of the costs are for labor rather than for raw material. A few thousandths of an inch less on the wall makes little difference in the final cost of the tubing. Actually, because of production problems, it may sometimes cost more to produce the light-wall tubing particularly when very thin walls are required. Underspecifying wall thickness results from two causes: 1. Failure to take into consideration that no tubing is perfectly concentric. Thin walls may not leave enough material for cleanup when machining the ID or OD. 2. Failure to allow for lot-to-lot variations.

When specifying tubing, any two of the cross-sectional dimensions—OD, ID, and wall thickness—may be specified, but not all three. Control of two dimensions automatically controls the third. Wall

tolerance with OD or ID, rather than OD and ID together, should be specified when:

1. Tubing is swaged, expanded, or similarly formed to change the OD and ID.
2. The tubing is used for heat transfer, as in heat exchangers, or is subject to pressure.
3. Either the OD or the ID is machined while the other surface is chucked.

On the other hand, wall tolerance is often unimportant and should not be specified if it is essential to control both the OD and ID. An example is the tubing for rocket clusters, where the volume of fluid flowing through the tubing must be closely controlled. Here, the best way is to specify the ID (and the OD) and forget about wall tolerance.

Recently, production of tubing by weight control (measuring the weight of carefully controlled lengths) has, for many applications, replaced production to wall-thickness specifications. In producing bourdon tubing, for example, the total mass of metal present in the tube is the most important factor, and the logical way to produce it is by weight control. Similarly, with tubing for flow applications, control of OD plus weight control gives the required internal volume without controlling either wall thickness or ID.

Standard wall tolerance is ±10 per cent of wall thickness on walls down to 0.005 in. and ±0.0005 in. on lighter walls. This may be reduced to 5 per cent of wall thickness, at extra cost, when required. Allowance is made for eccentricity in wall tolerances, Table 1.

While an extra-close wall tolerance is often desirable, it is commonly overspecified. In heat-transfer applications such as a thermocouple, for example, tubing is sometimes specified to a closer-than-commercial wall tolerance to eliminate the danger of burn-through. Actually, it costs less to specify tubing with a somewhat thicker wall and with commercial wall tolerances.

Specifying OD and ID: Commercial tolerances on all round ferrous, nonferrous, and corrosion-resistant alloy tubing are listed in Table 1 but may be reduced, at extra cost, to one-half these values. Frequently, even closer tolerances can be held on special orders. An extra-close OD tolerance may be important, for example, when expanding heat-exchanger tubing into a header or in nuclear-fuel tubing where close fit of the fuel inside the tubing promotes good heat transfer. Flow applications also require a close tolerance on the ID.

When tubing is to be machined, the worth of closer-than-commercial tolerances can be easily determined by balancing this cost against the additional machining cost which would otherwise be required. Often the availability of equipment for additional machining is the determining factor.

A point to remember in tubing specification is that the tolerance spread on both the OD and the ID can be applied to any degree desired on either the plus or minus side without paying a price premium. For example, a tolerance of 0.004 in. can be specified from plus 0.004, minus 0.000 in. to plus 0.000, minus 0.004 in. How much to specify on the plus and how much on the minus side depends on the application. Take, for example, the specification of tubing for a shaft to fit inside a reamed bushing. To avoid an interference fit, specify all of the OD tolerance on the minus side. On the other hand, if a tight fit is required, specify a small amount on the plus side.

Specifying Ovality: Normally, allowance is made for ovality or out-of-round in published size tolerances, Table 2. Ovality applies to both the OD and the ID and is usually important when the tubing must fit inside another part or when a solid material must pass through the tubing. With extra-close tolerances, addition of ovality to specifications adds to production problems and cost. It should not be specified unless required.

Specifying Straightness: All commercial round tubing is subject to a straightness tolerance of 1 part in 600. Straightness is important when long lengths must be located accurately in an assembly. In the production of parts on automatic machines, straightness facilitates stock feeding. Ordinarily, tubing is straightened after annealing. If dead-soft tubing is required, this procedure can be reversed to overcome slight work-hardening, but the tubing will not be as straight.

Specifying Tubing for Fitting Applications: The best specification for tubing which must fit inside another component or through which something must pass is the minimum specification which will do the job. For example, if tubing must pass freely through a hole, simply specify the diameter and length of the hole and the length of the tube. Further specifications will complicate the problem and will not necessarily improve performance. Ovality, straightness, and tolerance factors will all be taken care of in the tubing produced to such a specification.

In cases where a solid object must pass through the tube, specification can be simplified by furnishing the supplier with a gage corresponding to the solid and specifying the tubing size without a tolerance. The supplier can then produce tubing with the necessary roundness, straightness, and tolerance to permit passage of the solid object.

Specifying telescoping tubing is troublesome, particularly when a snug fit is desired, because tolerances on the mating diameters are combined to increase the over-all tolerance. The simplest way to solve this is to specify tolerances on only the outside or the inside tube and let the supplier furnish other tubing to give the desired fit. However, it is also necessary to specify the length of the telescoping tubes, since a loose fit on a short length can become a tight fit on a long one. Tubing can be produced so that tolerances on the high side on one tube compensate for tolerances on the low side on the other tube, and vice versa. In all cases, each size of

telescoping tubing should be ordered from the same supplier to insure a satisfactory fit.

Specifying Length: Tubing may be specified as random-length, multiple-length, or cut-length in order of increasing cost. Commercial random-length tubing is furnished in lengths from 1 to 15 ft if the tubing is under 1/8-in. OD and from 5 to 24 ft for diameters of 1/8 in. and larger. Random lengths from 17 to 24 ft are commonly known as long random lengths. Random lengths in the 5 to 24-ft category can be specified to a maximum spread of 7 ft or more without extra cost. For example, there is no extra charge for tubing furnished in lengths from 5 to 12 ft or 17 to 24 ft. There is, however, an extra charge for tubing from 5 to 10 ft long or from 19 to 24 ft long.

Random-length tubing is satisfactory for many applications particularly where the finished part is short and scrap loss is not great. To reduce scrap loss on longer parts, long straight lengths of tubing from 24 to 39 ft can be furnished at extra cost.

Multiple lengths—tubing which is furnished in multiples of a predetermined length—are available in three size ranges: Multiples under 3 ft, multiples from 3 to 6 ft, and multiples 6 ft and over. Extra costs apply to this length specification, but the savings in scrap loss may offset them and even permit substantial over-all savings.

Straight cut lengths can be supplied in any length up to the capacity of the draw bench and with length tolerances of a small fraction of an inch, Table 3. Cost is higher but scrap loss is eliminated. Cut lengths deserve special consideration when adequate tube-cutting facilities are not available in the fabricating plant or when facilities are overtaxed.

Lot-to-Lot Variations and In-Lot Variations: Generally, when cold drawing small tubing, it is easier to control variations within a lot than from one lot to another. Within a lot, tubing is subject to the same pickling, heat treatment, grinding, and other processes in the manufacturing cycle. It is difficult to maintain identical conditions for two or more lots. Therefore, it is advantageous to order tubing in the largest quantities practical.

Lot-to-lot variations are not necessarily detrimental since all tubing shipped meets specified tolerances. An effective way to reduce lot-to-lot variation is to specify closer-than-commercial tolerances at added cost. However, this may not be necessary for applications where another variable may be controlled. For example, the time delay in a circuit breaker is governed by the relative diameters of a metal slug and a metal tube in which it travels, and the viscosity of oil which surrounds the slug. Compensations can be made for lot-to-lot variations in the ID of the tubing by changing viscosity of the oil.

Exceptions to Specifications: The most frequent request for an exception to tubing specifications is in yield strength, tensile strength, or elongation. These properties can be varied widely provided that they are compatible.

Where a specification is subject to two interpretations, it is common practice for the supplier to assume the interpretation which fits its production capabilities. Conflict in specification results most frequently from using multiple government or industry specifications when ordering. Tubing should never be ordered to parts of different published specifications without first consulting the tube mill.

By its nature, small-diameter metal tubing poses unique problems in the lower size ranges. On very small tubing, for example, it is difficult to perform hardness tests. For greatest accuracy, tensile strength should be specified instead of hardness. The American Iron and Steel Institute recommends that hardness tests be limited to tubing above 1/4-in. ID and 0.049-in. wall.

Table 1—Commercial Tubing Tolerances*

Tubing OD (in.)	Tolerance on . . . OD (in.)	ID (in.)
Up to, but not including, 3/32	+0.002 −0.000	+0.000 −0.002
3/32 to, but not including, 3/16	+0.003 −0.000	+0.000 −0.003
3/16 to, but not including, 1/2	+0.004 −0.000	+0.000 −0.004
1/2 to, but not including, 1 1/2	+0.005 −0.000	+0.000 −0.005
1 1/2 to, but not including, 2 1/2	+0.010 −0.000	+0.000 −0.010

*Wall-thickness tolerance is ±10 per cent on all tubing sizes.

Table 2—Out-of-Round Tolerances

Tubing OD (in.) or Condition	Normal-Wall Tubing*	Light-Wall Tubing†
As drawn	Within commercial OD tolerance	....
To 1 1/2	....	Within 2 per cent of theoretical average OD
1 1/2 to, and including, 2 1/2	....	Within 2 1/2 per cent of theoretical average OD
Annealed or normalized	Within 2 per cent of theoretical average OD	Within 3 per cent of theoretical average OD
Heat treated	Within 2 per cent of theoretical average OD	Subject to agreement with supplier

*Any wall dimension 3 per cent or more but less than 25 per cent of the theoretical average OD.
†Any wall dimension less than 3 per cent of the theoretical average OD.

Table 3—Cut-Length Tubing Tolerances

Tube OD and Length	Length Variation (in.)
OD to 2 in., length up to, but not including, 1 ft	+1/32, −0
OD to 2 in., length 1 to 4 ft	+1/16, −0
OD over 2 in., length 1 to 4 ft	+3/32, −0
OD to 2 in., length over 4 to 10 ft	+3/32, −0
OD over 2 in., length over 4 to 10 ft	+1/8, −0
OD all sizes, length over 10 ft	+3/16, −0

Here's a practical technique for analyzing force, displacement, and velocity functions in . . .

Servo Feedback Systems

Complex problems in analysis of servo systems can be simplified by using three helpful tools:

1. Circuit diagrams, similar to those used in electrical circuits, in which displacement and force are analogies of voltage and current.

2. Resolution of practical element into "ideal" elements together with additional elements which represent losses, friction, and other passive elements.

3. Matrix and transfer-function algebra to determine required system characteristics, such as, displacement transfer-functions and input and output impedances.

J. M. NIGHTINGALE
Manchester, England

BASIC concept of electric circuit analysis is the relationship between potential drop E and current I in a passive two-terminal element, Fig. 1*a*. Linear analysis is based on the concept of impedance $Z(s)$:

$$E(s) = Z(s)I(s) \quad (1)$$

Equation 1 is algebraic if $E(s)$ and $I(s)$ are Laplace Transforms of the voltage and current.

By analogy, linear mechanical and hydraulic elements can be described by similar equations:

$$P(s) = Z(s)Q(s) \quad (2)$$

$$F(s) = Z(s)V(s) \quad (3)$$

Usually force F is chosen as the analog of potential E and velocity V as the analog of current I. However, there are advantages in choosing displacement X as the analog of potential E and force F as the analog of current I.*

The advantages of these latter analogies are: 1. Circuit connections are the same as the physical connections. 2. In servomechanisms, interest is normally in displacements rather than velocities. However, direct analogies with L, C, and R elements in electrical circuits is not possible with this convention. If this convention is used, Equation 3 is replaced by

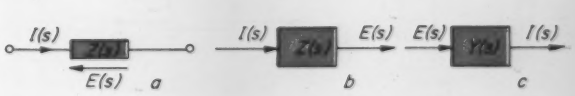
$$X(s) = Z(s)F(s) \quad (4)$$

A diagrammatic way of representing Equations 1, 2, and 4 is shown in Fig. 1*b*. In such block diagrams, arrowheads generally imply the sense of

*J. M. Nightingale—"Application of Circuit Analysis Techniques to Hydraulic Servomechanisms," Conference on Automatic Control, Heidelberg, 1956.

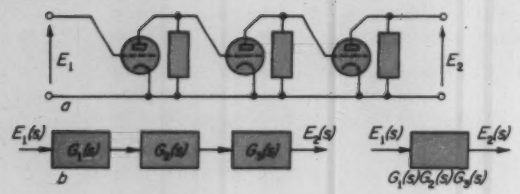
Nomenclature

A, B, C, D = Transmission matrix elements
E = Potential (voltage) difference
F = Force
$G(s)$ = Transfer function
I = Current
P = Pressure
Q = Flow rate
R = Transfer ratio of lossless transducer
V = Velocity
X = Displacement
Y = Admittance
Z = Impedance

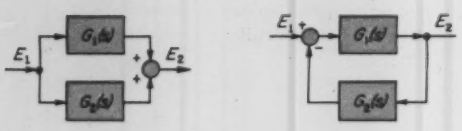


1

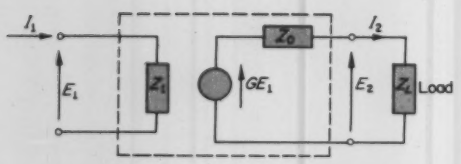
Diagram of passive two-terminal element: *a*, conventional representation, *b*, voltage as controlled variable and, *c*, current as controlled variable.



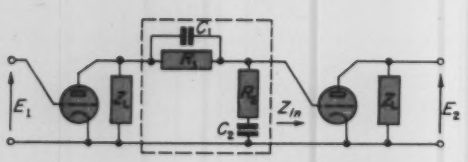
2 Three-stage electronic amplifiers: *a*, circuit diagram and, *b*, block diagram.



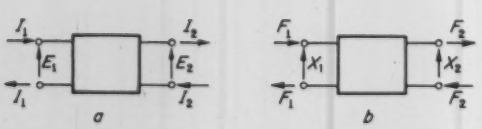
3 Block diagrams of parallel transmissions for, *a*, addition of feed forward signals and, *b*, subtraction of feedback signals.



4 Circuit diagram of a unidirectional amplifier. To account for current drawn from the signal source and potential drop due to current drawn by load Z_L, an input impedance Z_i and output impedance Z_o are introduced.



5 Open-circuit characteristics of the network are approximately proportional, integral, and derivative. However, when used as an interstage network, the overall transmission characteristics are affected by the gain and internal impedances of the amplifiers.



6 Loading represented by four-terminal circuit elements. Two equations are needed to relate the four variables at the terminals, and the device may be, *a*, entirely electrical or, *b*, entirely mechanical, or a combination of the two.

cause and effect. However, in block diagrams representing circuits, there is often no unique cause-effect relationship. Hence, the representation in Fig. 1c can be used equally well. In this diagram, $Y(s) = 1/Z(s)$ is the admittance of the element.

When the circuit elements have transmission properties, a transfer function, $G(s)$, is usually defined. For example, in a voltage amplifier,

$$E_2(s) = G(s)E_1(s) \tag{5}$$

Algebraic reduction of block diagrams can be performed if successive elements do not interact. For instance, Fig. 2*a* shows a cascade of three ideal amplifiers. If the gain of each stage is independent of the other stages, the block diagram can be reduced as shown in Fig. 2*b*. Hence, the over-all transfer function is

$$G(s) = G_1(s)G_2(s)G_3(s) \tag{6}$$

This algebraic principle can be extended to any number of cascaded elements, and in theory, the order of elements does not effect the transfer function.

In addition to cascade connections, there are two forms of parallel arrangements, Fig. 3. The over-all transfer function for feedforward is

$$G(s) = G_1(s) + G_2(s) \tag{7}$$

For feedback,

$$G(s) = \frac{G_1(s)}{1 + G_1(s)G_2(s)} \tag{8}$$

All control systems consist of various interconnected elements in cascade and parallel. Hence, the block-diagram algebra can be systematically applied to reduce the system to a single transfer function.

In practical amplifiers, gain depends on output load. In the same way, the amplifier loads its own signal source to a certain extent. In simple unidirectional amplifiers, this interaction is accounted for by introducing input and output impedances of

Overall Matrix	Case 1
A	$\frac{A_1A_2}{A_1 + A_2}$
B	$\frac{A_1B_2 + A_2B_1}{A_1 + A_2}$
C	$\frac{A_1C_2 + A_2C_1}{A_1 + A_2}$
D	$\frac{(A_1+A_2)(D_1+D_2) - (B_1-B_2)(C_1-C_2)}{A_1 + A_2}$

*Refers to arrangements shown in Fig. 12.

Z_1 and Z_0 respectively, Fig. 4.

By proper design, the effect of interaction can often be made negligible, particularly in electronic circuits. However, in active mechanical circuits, the effect of loading must often be considered.

Loading effects are very important in interstage compensating networks. In Fig. 5, the open-circuit transmission characteristics of the network are chosen to give action which is approximately proportional + integral + derivative in nature. However, when the network is installed as shown, loading of the network, as well as gain characteristics of the amplifiers, influence the over-all transfer function.

It is possible to account for interaction by treating each element as a four-terminal device, Fig. 6. Two equations are needed to relate the four variables at the terminations. These may be expressed in a number of alternative ways. For example,

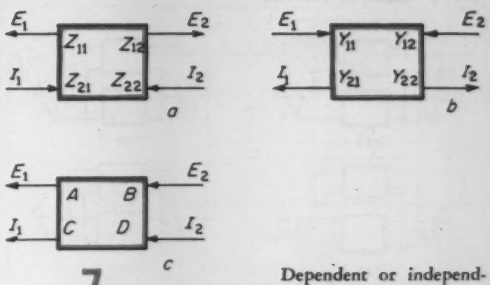
$$E_1 = Z_{11} I_1 + Z_{12} I_2$$
$$E_2 = Z_{21} I_1 + Z_{22} I_2 \qquad (9)$$

$$I_1 = Y_{11} E_1 + Y_{12} E_2$$
$$I_2 = Y_{21} E_1 + Y_{22} E_2 \qquad (10)$$

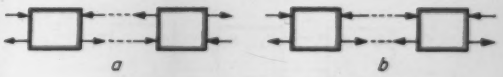
$$E_1 = A E_2 + B I_2$$
$$I_1 = C E_2 + D I_2 \qquad (11)$$

It is also possible to represent four-terminal devices by block diagrams, Fig. 7. These diagrams correspond in turn to the forms of Equations 9, 10, and 11. The arrowheads indicate the independent and dependent variables; the boxes contain the various coefficients.

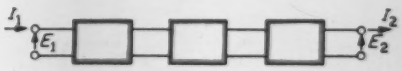
Although these alternate forms are useful, the actual designation is determined by the end conditions which must be satisfied when elements are interconnected. Hence, the designations shown in Fig. 8*a* are compatible; those in Fig. 8*b* are incompatible since arrow directions do not concur.



7 Dependent or independent variables represented by arrowhead direction in block diagrams. Coefficients of the variables are written in matrix form inside the blocks.



8 Arrowhead directions concur in, *a*, compatible designation, and do not concur in, *b*, incompatible designation.



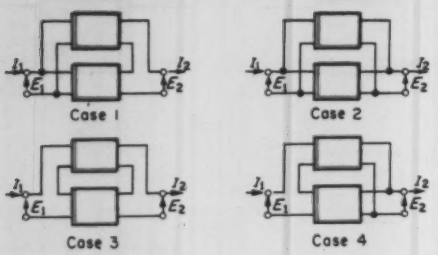
9 Physical connections of cascade-connected elements.

Physical Connections

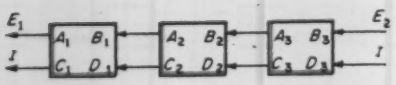
When interactions cannot be neglected, control systems are considered as numerous four-terminal devices connected in cascade or parallel. Matrix alge-

Table I—Overall Matrices for Parallel Connections

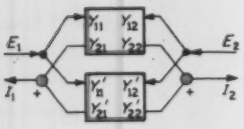
Parallel Connection*		
Case 2	Case 3	Case 4
$\frac{A_1B_2 + A_2B_1}{B_1 + B_2}$	$\frac{A_1C_2 + A_2C_1}{C_1 + C_2}$	$\frac{(A_1+A_2)(D_1+D_2) - (B_1-B_2)(C_1-C_2)}{D_1 + D_2}$
$\frac{B_1B_2}{B_1 + B_2}$	$\frac{(B_1+B_2)(C_1+C_2) - (A_1-A_2)(D_1-D_2)}{C_1 + C_2}$	$\frac{B_1D_2 + B_2D_1}{D_1 + D_2}$
$\frac{(B_1+B_2)(C_1+C_2) - (A_1-A_2)(D_1-D_2)}{B_1 + B_2}$	$\frac{C_1C_2}{C_1 + C_2}$	$\frac{C_1D_2 + C_2D_1}{D_1 + D_2}$
$\frac{B_1D_2 + B_2D_1}{B_1 + B_2}$	$\frac{C_1D_2 + C_2D_1}{C_1 + C_2}$	$\frac{D_1D_2}{D_1 + D_2}$



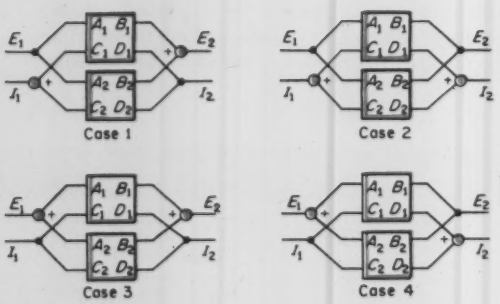
10 Physical connections of parallel-connected elements.



11 Block diagram of cascade-connected elements. *ABCD* matrices are used since overall transmission characteristics are simply obtained by matrix multiplication.



12 Block diagram of parallel combination. Overall characteristics are obtained by matrix addition.



13 Simplified block-diagram form for parallel elements. Arrowheads are omitted, and overall *ABCD* elements for the various combinations are listed in Table I.

bra can fulfill a role in describing the four-terminal devices similar to that played by transfer-function algebra in describing noninteracting systems. Fig. 9 shows a circuit diagram for cascade-connected elements. Various parallel transmissions are possible, Fig. 10.

Matrix Notation

Equations 9, 10, and 11 can conveniently be written in matrix form:

$$\begin{bmatrix} E_1 \\ E_2 \end{bmatrix} = \begin{bmatrix} Z_{11} & Z_{12} \\ Z_{21} & Z_{22} \end{bmatrix} \begin{bmatrix} I_1 \\ I_2 \end{bmatrix} \quad (12)$$

$$\begin{bmatrix} I_1 \\ I_2 \end{bmatrix} = \begin{bmatrix} Y_{11} & Y_{12} \\ Y_{21} & Y_{22} \end{bmatrix} \begin{bmatrix} E_1 \\ E_2 \end{bmatrix} \quad (13)$$

$$\begin{bmatrix} E_1 \\ I_1 \end{bmatrix} = \begin{bmatrix} A & B \\ C & D \end{bmatrix} \begin{bmatrix} E_2 \\ I_2 \end{bmatrix} \quad (14)$$

The form of Equations 12 and 13 suggests that the boxes in Fig. 7 are, in effect, appropriate square matrices and can be used as such. For the cascaded elements, Fig. 11, it is more convenient to use the *ABCD* or transmission matrix form. The over-all transmission matrix is obtained simply by matrix multiplication. Hence,

$$\begin{bmatrix} A & B \\ C & D \end{bmatrix} = \begin{bmatrix} A_1 & B_1 \\ C_1 & D_1 \end{bmatrix} \begin{bmatrix} A_2 & B_2 \\ C_2 & D_2 \end{bmatrix} \begin{bmatrix} A_3 & B_3 \\ C_3 & D_3 \end{bmatrix} \quad (15)$$

Matrix multiplication can be repeated for products of more than two matrices, but order of multiplication cannot be interchanged like transfer functions.

If block diagrams are used with designated arrowheads, the arrowheads must be matched when elements are connected in parallel. This connection determines the conventions used for the individual boxes, Fig. 12. The arrangement of inputs and outputs in Fig. 12 suggests that Equation 13 is best suited for expressing this parallel combination in matrix form. Hence, the over-all relation is

$$\begin{bmatrix} I_1 \\ I_2 \end{bmatrix} = \begin{bmatrix} Y_{11} & Y_{12} \\ Y_{21} & Y_{22} \end{bmatrix} \begin{bmatrix} E_1 \\ E_2 \end{bmatrix} + \begin{bmatrix} Y_{11}' & Y_{12}' \\ Y_{21}' & Y_{22}' \end{bmatrix} \begin{bmatrix} E_1 \\ E_2 \end{bmatrix}$$

$$= \begin{bmatrix} Y_{11} + Y_{11}' & Y_{12} + Y_{12}' \\ Y_{21} + Y_{21}' & Y_{22} + Y_{22}' \end{bmatrix} \begin{bmatrix} E_1 \\ E_2 \end{bmatrix} \quad (16)$$

Although this is the simplest way of combining the characteristics of the two elements, the over-all matrix would have to be transformed to *ABCD* form if other elements were cascaded with the parallel combination. Instead of performing this lengthy transformation it would be simpler to use *ABCD* matrices throughout. If the usual convention of arrowheads is dispensed with, a simple form of block diagram can be drawn, Fig. 13. For these constructions the elements of the over-all *ABCD* matrix are expressed in terms of the matrices of the individual elements. These matrix combinations are given in Table 1.

Passive Elements: Fig. 14*a* shows a passive two-terminal element in series with the transmission. Similarly, Fig. 14*b* shows the parallel connection of a passive two-terminal element. The *ABCD* matrices for these arrangements are shown on the respective diagrams.

Ideal Amplifiers: Practical unilateral amplifiers are diagrammed as ideal amplifiers with passive impedances. Representations for various ideal electrical amplifiers are shown in Fig. 15, together with

their *ABCD* matrices. Hydraulic valve amplifiers and other forms of amplifiers have similar representations.

The block diagram for the practical amplifier of Fig. 4 is shown in Fig. 16. For push-pull or differential amplifiers a simple block diagram similar to the practical amplifier can be drawn if the two halves of the amplifier are balanced.

Lossless Transducers: Ideal transformers, motors, and piston transducers are typical lossless transducers. The effect of friction, inertia, compressibility, and internal losses can be included as passive elements in the transmission line.

Since there is no loss of power in these elements, $E_1 I_1 = E_2 I_2$. If the voltage ratio is $E_2/E_1 = R$, then the *ABCD* matrix can be written as

$$\begin{bmatrix} \frac{1}{R} & 0 \\ 0 & R \end{bmatrix} \tag{17}$$

Applications

A typical servomechanism is shown schematically in Fig. 17*a* while Fig. 17*b* shows the block diagram. The block diagram can be systematically reduced: First by combining the cascaded elements, then by combining the two parallel paths. This reduction leads to the over-all matrix elements:

$$A = \frac{G + (Y_1 + Y_2)R}{G + Y_1 R}$$

$$B = \frac{R}{G + Y_1 R}$$

$$C = \frac{Y_1 Y_2 R}{G + Y_1 R}$$

$$D = \frac{Y_1 R}{G + Y_1 R} \tag{18}$$

Once these matrix elements are found, certain system functions of interest in design can be determined. For example, the displacement transfer function is

$$\left.\frac{X_2}{X_1}\right]_{F_2=0} = \frac{1}{A} = \frac{G + Y_1 R}{G + (Y_1 + Y_2)R} \tag{19}$$

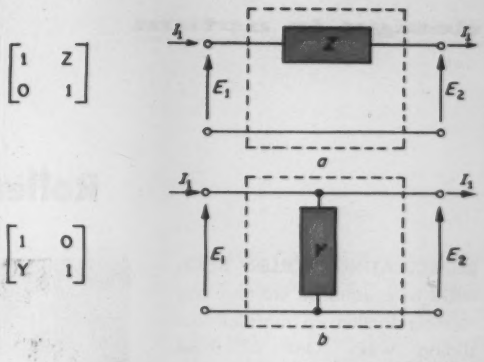
Similarly, the input impedance is

$$\left.\frac{X_1}{F_1}\right]_{F_2=0} = \frac{A}{C} = \frac{G + (Y_1 + Y_2)R}{Y_1 Y_2 R} \tag{20}$$

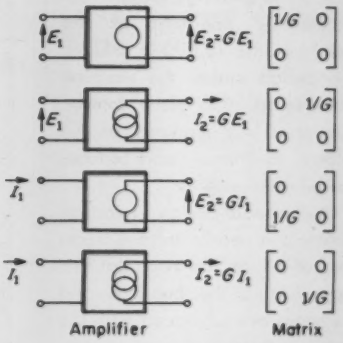
For the output impedance,

$$-\left.\frac{X_2}{F_2}\right]_{x_1=0} = \frac{B}{A} = \frac{R}{G + (Y_1 + Y_2)R} \tag{21}$$

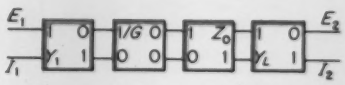
Methods outlined in this article supplement the transfer-function analyses and are particularly suited for application when the effects of loading and interaction between elements are not negligible. Use of matrix algebra provides a methodical approach to the analysis and design of feedback systems.



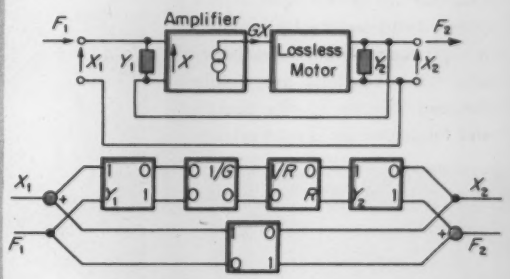
14 Passive two-terminal elements encountered in series or parallel with transmission.



15 Practical amplifiers divided into ideal amplifiers with passive elements. The circuit representation and *ABCD* matrices are shown for ideal unidirectional electrical amplifiers. Other forms of amplifier receive similar treatment.



16 Block diagram with appropriate matrices for simple practical amplifier. Overall characteristics are obtained by matrix multiplication.

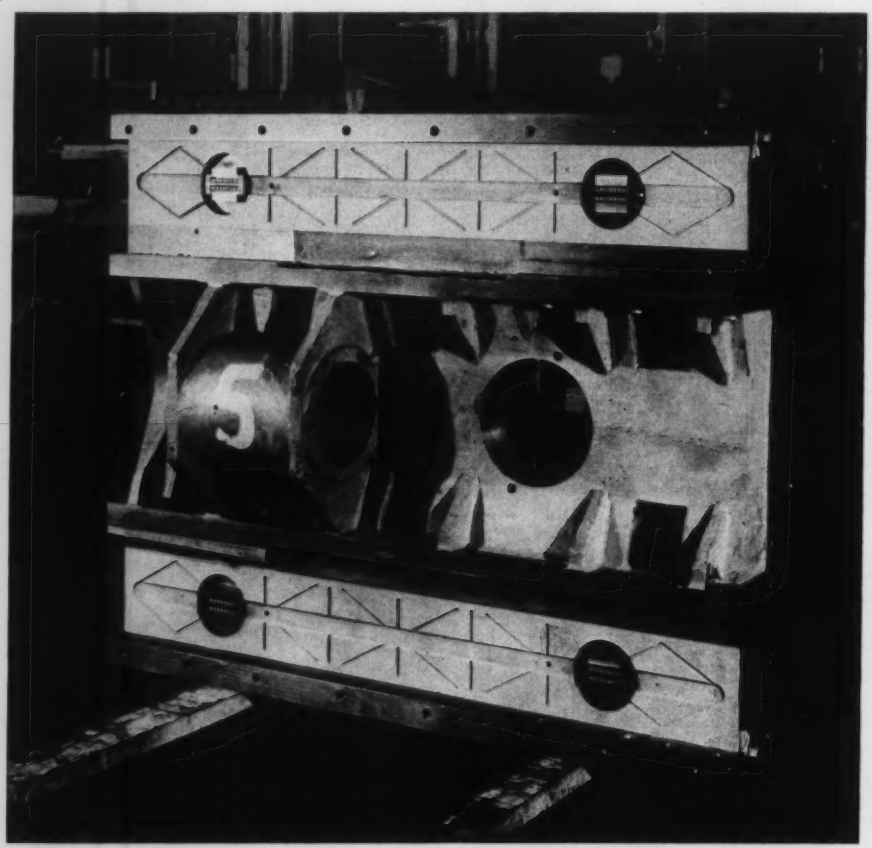


17 Simple servomechanism for feedback. Forward path in schematic, *a*, includes ideal amplifier and lossless motor, together with admittances Y_1 and Y_2. Other passive elements can be included to account for other losses. Block diagram, *b*, depicts various matrices involved.

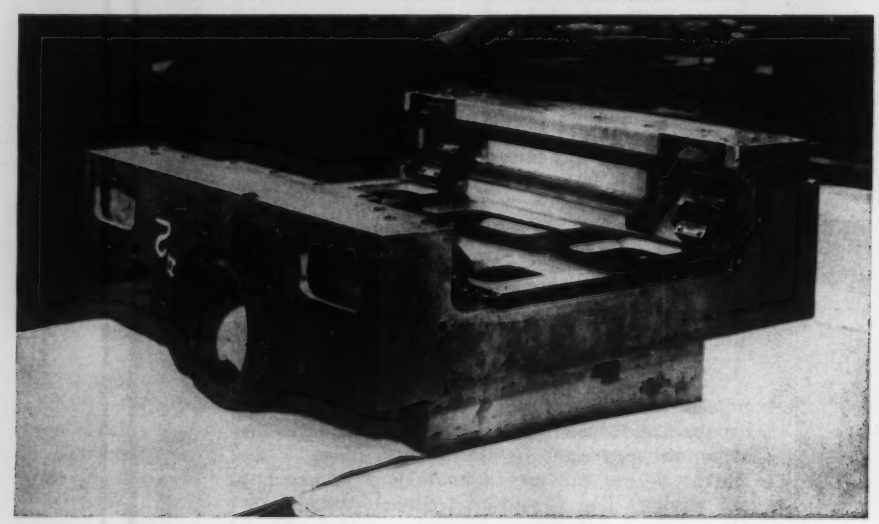
Roller Bearings Between Sliding Ways

RECIRCULATING ROLLER BEARINGS help equalize starting and running friction on machine-tool sliding ways. One of these special bearings is mounted under each corner of the column shoe. The bearings support approximately one-third of the weight of the 10,000-lb column. The design makes the machine more sensitive to servo control, eliminates any tendency of the column to fishtail, and reduces power requirements.

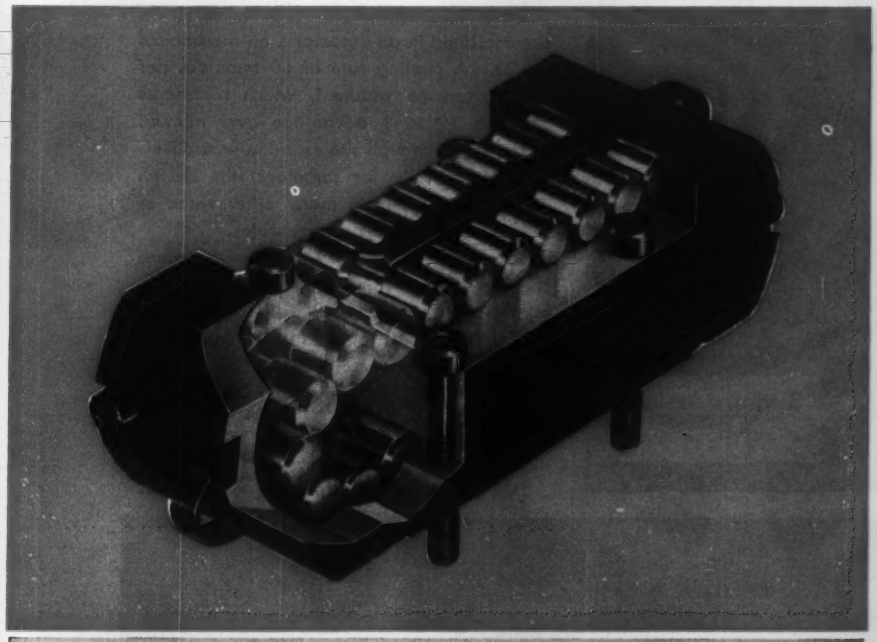
The special-design bearings maintain a nearly uniform thickness of oil on the two, flat-bed ways. Both the bearings and the ways are lubricated with the same oil through a labyrinth system built in the shoe.



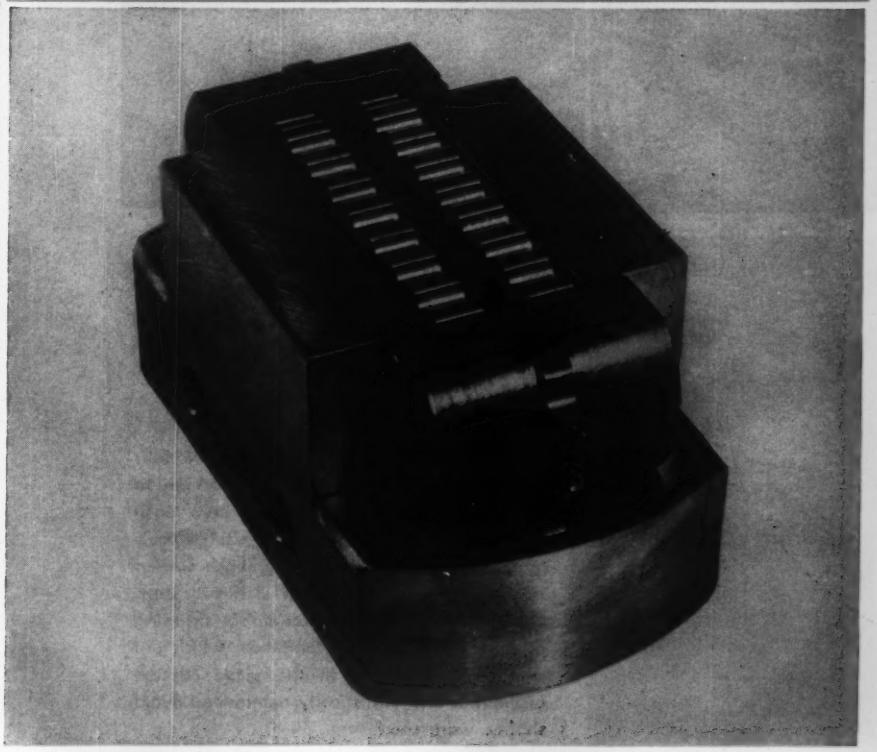
ALIGNMENT ACCURACY of ±0.0002 in. is achieved in the spindle-head saddle by building in eight recirculating roller bearings. The bearings are rigidly clamped directly to the saddle and lubricated by a mist system.



Increase Servo Positioning Sensitivity



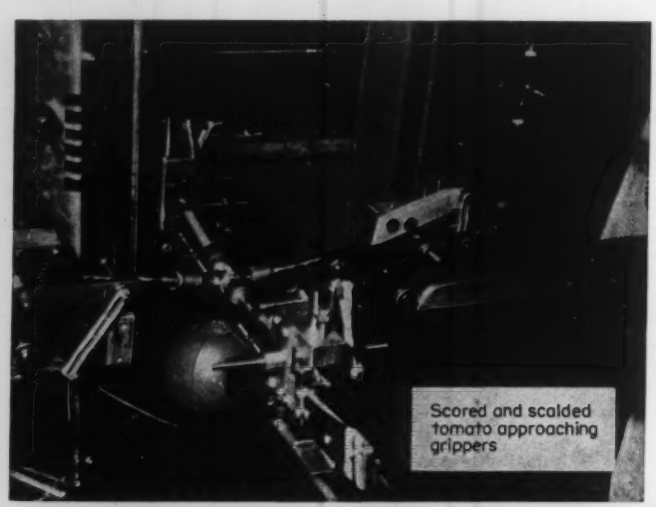
ROLLERS CIRCULATE through a return channel within the bearing race. In this application, the mating way of the machine acts as the other race. These Tychoway bearings, manufactured by Scully-Jones and Co., are made of through-hardened 52100 bearing steel.



BEARING MOUNTING CLAMP is seated on the race rolling surface and the bearing pad. The design permits high clamping forces and offers an extremely stiff bearing assembly. A spring between the pad and frame member preloads the bearing.

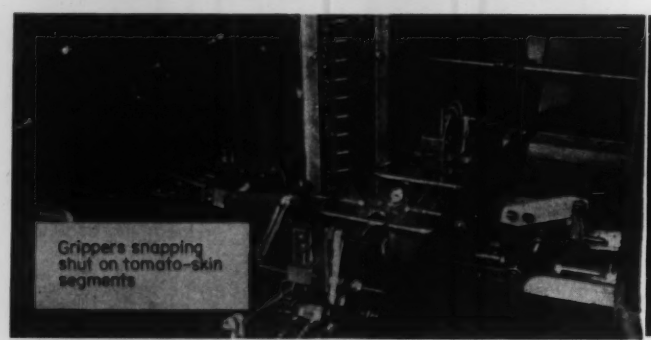
REPEAT POSITIONING ACCURACY of 0.0001 in. is achieved in this automatic machine tool manufactured by Kearney and Trecker Corp. The automatic changer handles as many as 31 different tools for machining operations which vary from small-hole drilling to heavy milling.

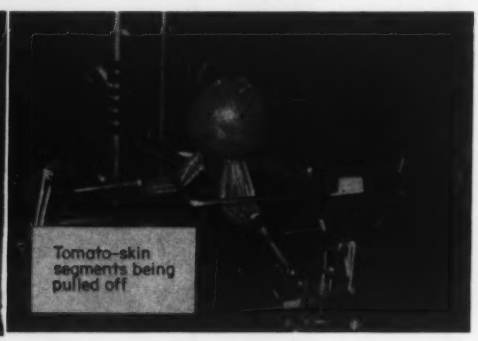
Adjustable-Shape Cam in Linkage

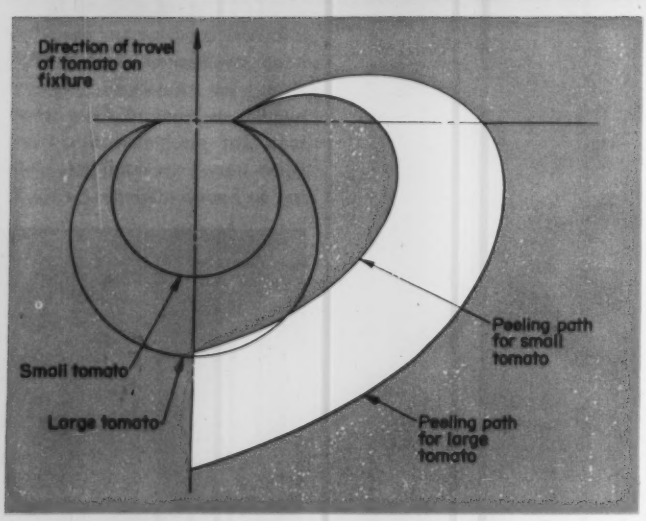


HIGH-SPEED PEELING of tomatoes is easily accomplished in an automatic, all-mechanical peeler. A peeling rate of 60 tomatoes per minute can be attained, which represents about a 12 to 1 advantage over manual methods. Although the machine was developed specifically for tomatoes, the design could be adapted to many other types of thin-skinned fruits and vegetables.

Successful mechanical peeling of tomatoes requires a positive method of gripping the ends of skin segments as well as a peeling mechanism which automatically adjusts to the size of each tomato. Both of these basic design requirements are met in this working prototype developed by Edwin C. Hardesty and William E. Stalhuth, Baltimore, Md.






Direction of travel of tomato on fixture
Peeling path for small tomato
Small tomato
Large tomato
Peeling path for large tomato

INVOLUTE-LIKE PATHS OF TRAVEL of the four peeling mechanisms permit the machine to literally unwrap skin segments from each tomato. A different shape and size of peeling path must be followed for each size of tomato to avoid tearing of skin segments. The diagram illustrates acceptable stripping paths for two sizes of tomatoes, which are considered spheres. In the actual design of the machine, statistically determined ovoid shapes were used.

Produces Several Paths of Motion

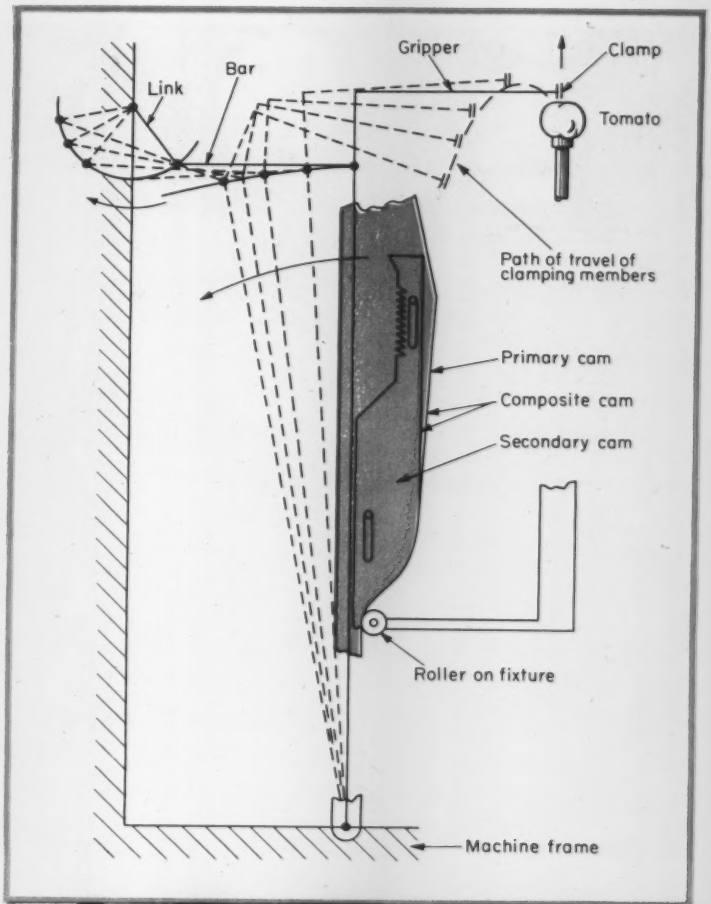
COMPOSITE-CAM "LINK" in the four-bar linkage in each of the four peeling mechanisms provides automatic adjustment to match individual tomato size and shape. The composite cam is made up of two sections—a primary cam and a secondary cam.

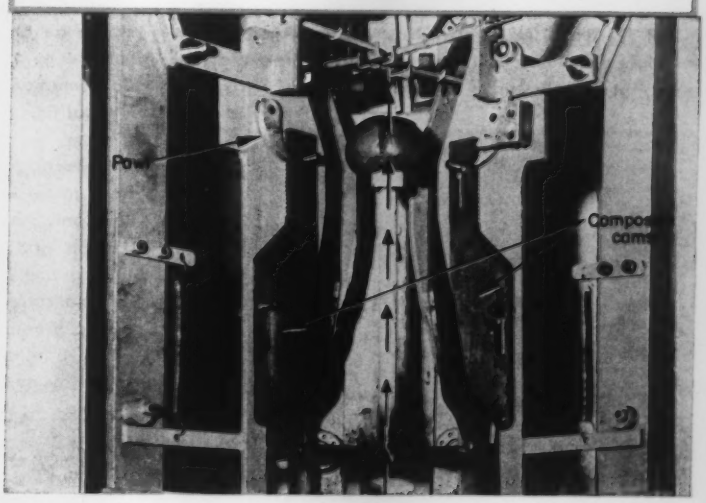
A gripper member is mounted on an extension of the bar on each of the four-bar linkage peeling mechanisms. A self-locking clamp of patented design is mounted on the end of each gripper member.

As a fixture carrying a scalded and scored tomato approaches the peeling section of the machine, four rollers make contact with the secondary cams on each of the four peeling mechanisms. Each roller lifts each secondary cam and causes overlapping with its associated primary cam. When the top of the tomato touches the open clamps on the ends of the four grippers, these clamps trigger shut astraddle the four skin segments. At the same time, a rod in each gripper member causes a pawl to engage the teeth on each secondary cam. This action locks the primary and secondary cam together in each peeling mechanism. To assure proper stripping of odd-shaped tomatoes, each of the four peeling mechanisms operates independently.

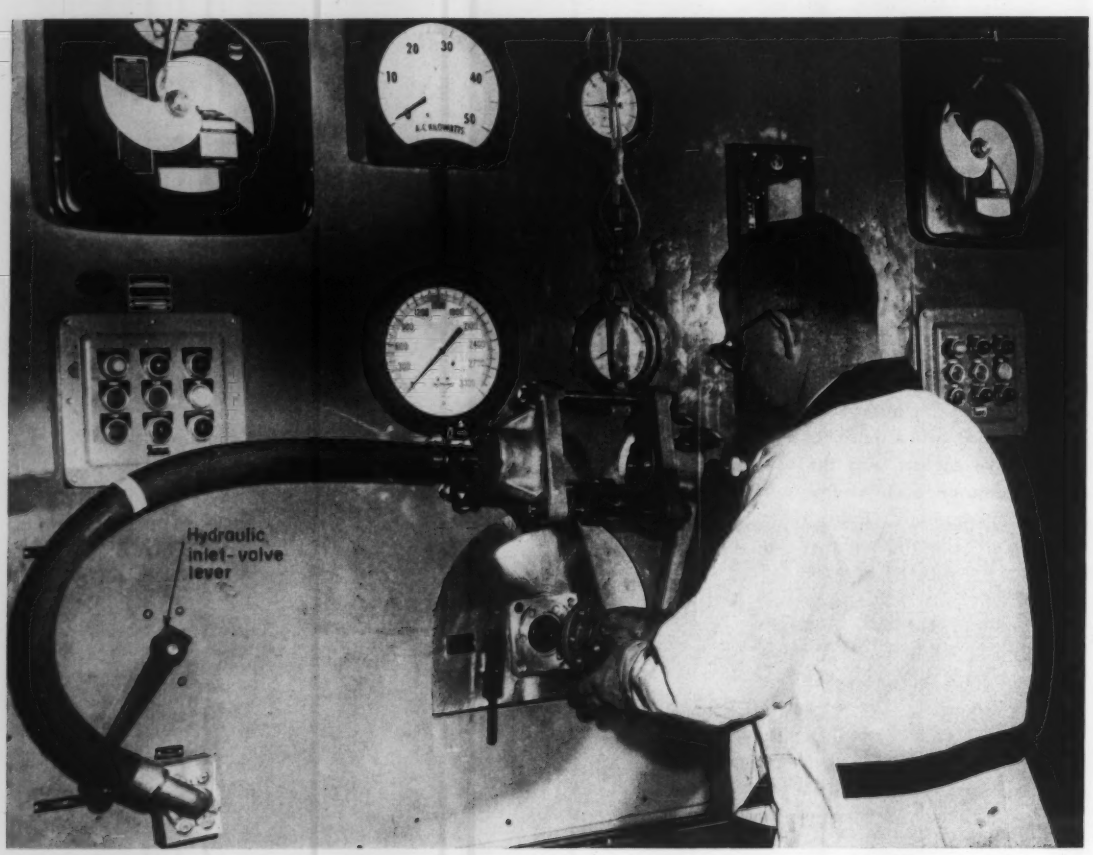
The upwardly traveling rollers on the fixtures begin to operate the four-bar linkages by actuating their respective composite cams. The composite-cam contour provides the proper path of motion for each of the peeling clamps with respect to the moving tomato.

At the end of the return stroke of the four-bar linkage, the clamps are open and secondary cams have moved to their lowest position ready to sense the size of the next tomato.





Quick-Connect Hydraulic Test Harness



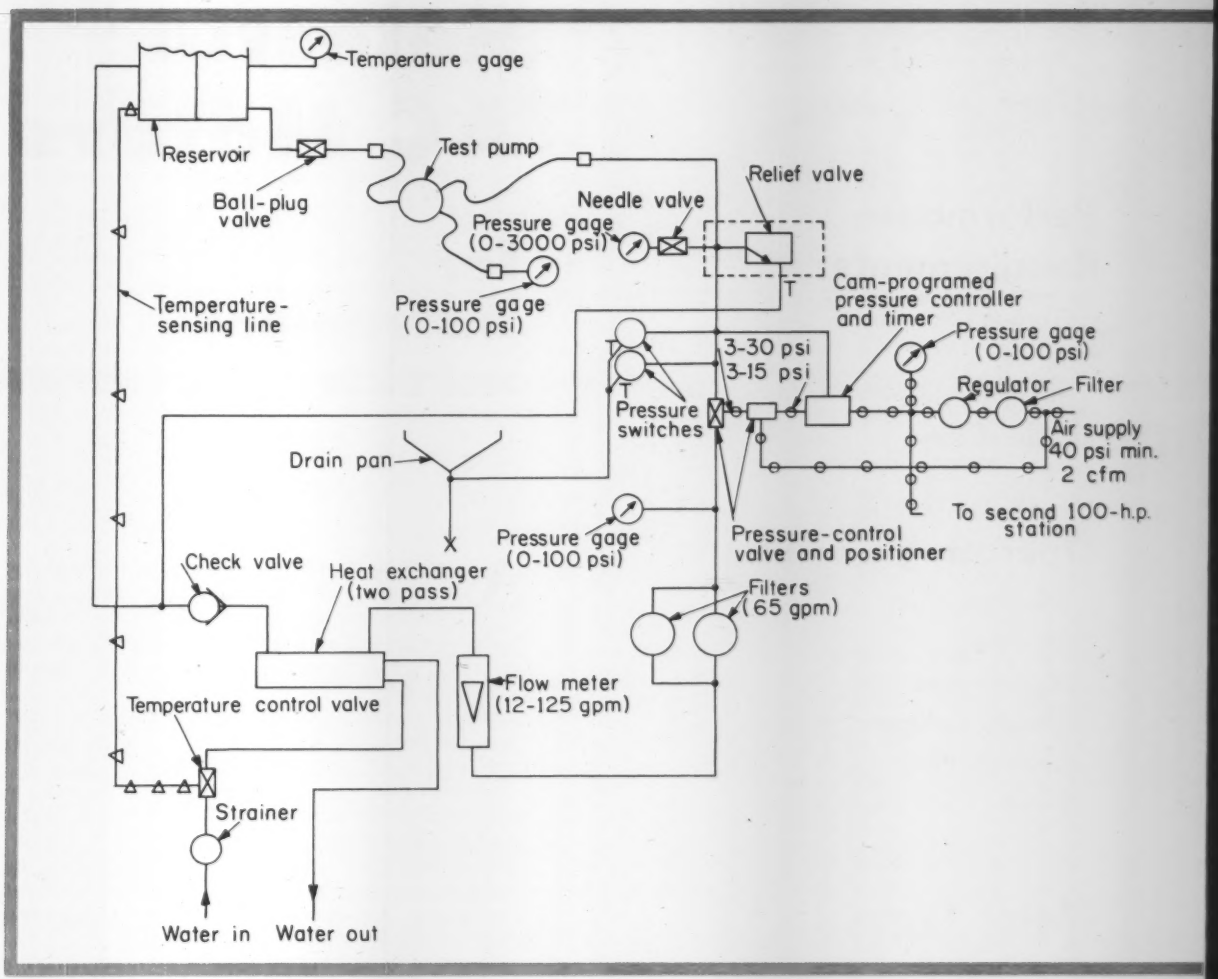
PUMP TESTING TIME is saved by a special-design unit for connecting and disconnecting hydraulic lines to pump ports. The quick-connect hydraulic-line coupler was designed for an automatic production-pump test stand developed by the Hydraulic Products Div., Clark Equipment Co., Benton Harbor, Mich.

Total time for mounting, connecting, and disconnecting a pump to the test stand is about 20 sec. With the harness, no more than 10 sec is needed to connect pump ports to the inlet tank and the discharge system.

A previous system required 15 to 20 min to mount, connect, and disconnect a pump from the test stand.

Programming cam on the electropneumatic controller automatically varies the pressure applied to each pump during a normal 1-hr test period. The plate cam, made of 1/16-in. sheet aluminum, is driven at the required speed by an electric timing motor.

Clamps over Pump Ports in 10 Seconds



AUTOMATIC TESTING CYCLE starts when the operator opens the hydraulic inlet valve and pushes the start button on the electric motor driving the pump under test.

During the first 30 min of test, the pump is driven at 1000 rpm, and the applied hydraulic pressure is raised gradually from 100 to 2000 psi by the electropneumatically controlled scheduling valve.

After the first 30-min test period, pressure is dropped to 100 psi, and pump speed is increased to 2000 rpm. The cam-operated controller again varies the pressure linearly from 100 to 2000 psi.

During the testing cycle, the operator checks the flow meter and torque meter to see if the pump meets design operating requirements.

Drive Functions

- Positioning
- Timing
- Remote control
- Power

Performance Requirements

- Torque
- Speed
- Response time
- Type of duty

Operating Conditions

- Electrical input
- Mounting
- Environment
- Weight and space
- Shaft-coupling
- Noise

Motor Types

- Synchronous
  - Reluctance
  - Hysteresis
  - Polarized
- Induction
  - Standard slip
  - High slip
  - Dynamic brake
- Servo
- Standard or special

Key factors in

Selecting AC Motors for instrument service

AS a class, instrument motors are designed for positioning, timing, and remote control, frequently for servo or other control service. Instrument motors are much like other motors, except they are designed to satisfy needs peculiar to instrument drives.

Picking the right one requires that the conventional selection criteria be checked: Power, torque, speed, duty cycle, mounting method, etc.

But instrument motors are designed to meet drive requirements that may be more critical than found in other applications.

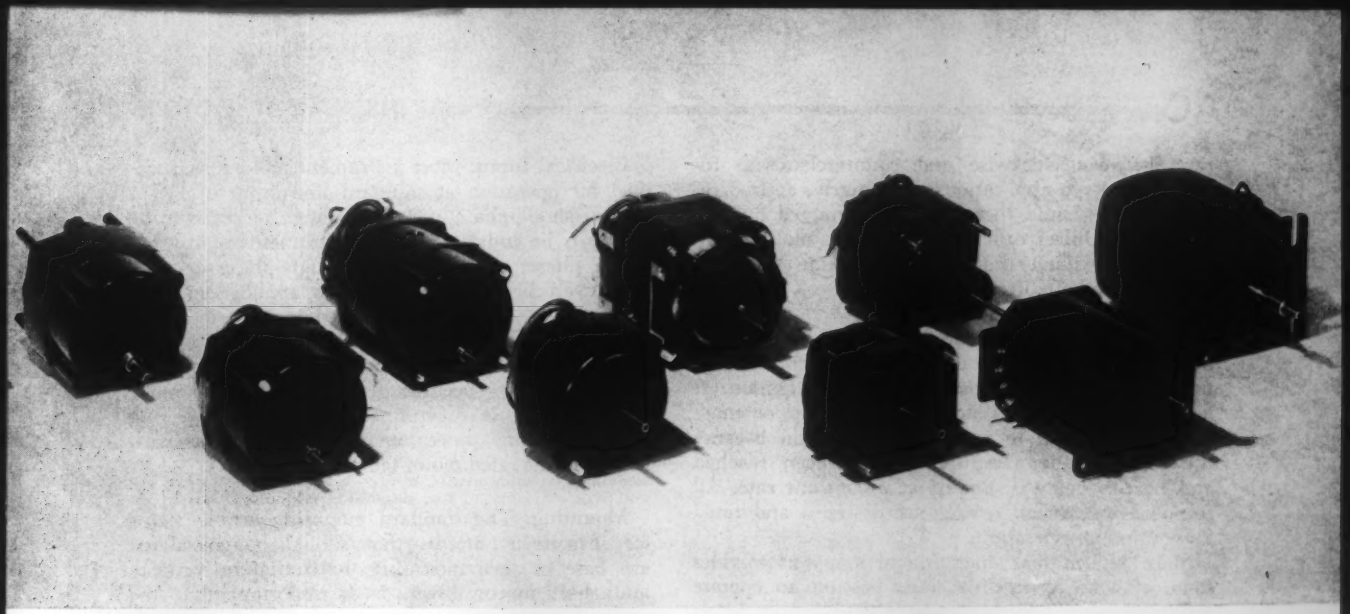
Must the motor respond quickly? Must speed be constant? Is quiet operation necessary? Is space at a premium? Will the motor be accessible for servicing?

Complete specifications require accurate answers to these and many other questions. An organized approach is outlined here for selecting the right instrument motor.

Performance Requirements

Torque, speed, response time, and type of duty are of major importance in specifying an instrument motor. The manner in which each of these performance requirements is specified depends, of course, on the particular function.

Torque: Starting torque is defined as the minimum value required to start an instrument drive system. It may be necessary to specify maximum



Typical commercial instrument motors and gear motors ranging in size from 2¼ to 3¼-in. diameter.

ROBERT MATTHEWS Chief Engineer, Holtzer-Cabot Divs., National Pneumatic Co. Inc., Boston, Mass.

starting torque on low-speed gear motors to prevent damage to the driven system.

Running torque is that torque which is necessary to maintain the load at desired speed and is either constant or variable. Variable running torque may be encountered, for example, when a motor rotates a cam which has a varying, although cyclical, follower load. In such cases the load cycle should be described, including maximum torque, minimum torque, and the frequency or period of the cycle.

Speed: Usually speed is specified in revolutions per minute of the motor output shaft. Motors are readily available, with and without gear reduction, in speeds of 3600 to ½ rpm. Timing applications naturally require an exact constant speed. This is the synchronous speed of an ac motor and is proportional to input frequency. Synchronous speed is a constant value for a given constant-frequency source. In power applications, speed need not be constant and is usually specified as a nominal speed, permitting the use of induction motors. While speed is not a primary criterion in servo motors, it is usually desirable to give a specified speed at a particular torque based on maximum allowed response time.

Response Time: The time for the motor to accelerate from rest to the desired speed should be specified when it is important. Response time is specified as either a maximum number of milliseconds to reach a desired speed or minimum acceleration of radians per second per second. Response time is specified in servo applications and often in timing devices in which successive timing cycles occur rapidly. Where very rapid response is required in timing and recording applications, it may be best to provide a clutch mechanism to connect the system to a continuously running motor.

There is usually a minute variation in response

Table 1—Drive Functions of Instrument Motors

Drive Function	Operating Requirements
Servo balancing or positioning	To respond to an electrical error signal and rotate in the proper direction and proportional magnitude to correct the original system error.
Timing	To maintain continuous linear or rotational motion at a constant speed.
Remote control	To position remotely at a fixed speed of linear or rotational motion within a desired response time.
Power	To provide sufficient power to maintain linear or rotational motion at a relatively constant speed.

time between clockwise and counterclockwise rotation. In servo applications particularly, desired response time should therefore be determined in both directions. Unless otherwise indicated, motor manufacturers assume that a response-time specification refers to both directions.

Type of Duty: Operation of the motor on continuous or intermittent duty is most important in terms of temperature rise and heat dissipation. A motor which has run steadily for 1 hour or more is assumed to be in continuous operation because the maximum temperature rise has been reached and heat is being dissipated at a constant rate. All standard instrument motors are designed and rated for continuous operation.

Since intermittent operation of a motor provides some off-time for cooling, it is possible to operate an instrument motor at torque and power levels that exceed the continuous-duty ratings. The allowable increases over motor ratings depend on the particular duty cycle, and should be specified after consultation with the motor manufacturer. Motors which are designed for intermittent service should not be used continuously or even at significantly increased "on" time.

A motor's sensitivity and speed of response can be improved by "dithering." The control winding of a servo motor receives a signal directly from the output of an amplifier, while the reference winding is provided with continuous 60-cps line excitation. When there is no ac excitation signal through the amplifier, a dc plate voltage remains on the control winding. Because the rotor has a polarity induced by the ac signal in the reference winding, the rotor oscillates rapidly in a small angle between pairs of poles. The oscillation is called dithering. It minimizes starting friction when an ac control signal of either polarity energizes the control winding so that starting voltage is substantially reduced. If there were no dc signal in the control winding, there would be no oscillation and full starting friction would have to be overcome.

Operating Conditions

The most significant operating conditions which must be given in instrument-motor specifications are:

1. Electrical Input—voltage, current, power, frequency
2. Method of Mounting
3. Environmental Factors
   a. Temperature
   b. Atmospheric conditions
4. Weight and Space Available
5. Shaft Coupling
   a. Direct
   b. Flexible coupling
   c. External gearing
   d. End and side thrust

Electrical Input: Most instrument motors are specified for operation at standard line input of 115-v, 60-cps, single-phase power. A range of input voltages can be indicated. Most instrument motors are single phase, although either single-phase or two-phase can be obtained. In servo applications it is important to specify the required impedance in the control winding at locked rotor and minimum starting voltage. The maximum amplifier power available should be specified. The power in the reference winding is determined on the basis of the control-winding power and the duty cycle with respect to the rated motor temperature.

Mounting: The standard mounting arrangements for instrument motors that should be considered are base or face mounting, horizontal or vertical, and shaft up or down. It is important that the motor be properly secured so that resonant noise or loosening of connections cannot occur.

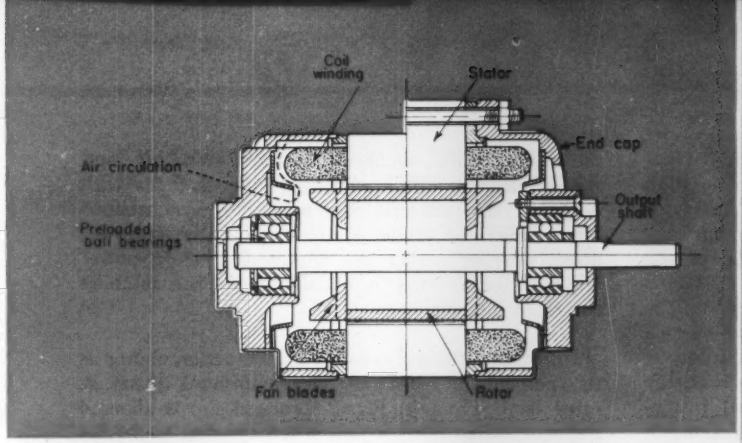
Environmental Factors: The first consideration is ambient temperature. Most standard instrument motors available today have an allowable rise in temperature of 65 deg C of the windings measured by resistance. The total temperature of the motor, in the windings, should not exceed 105 C (221 F). Since this total temperature is the sum of the motor temperature rise and ambient temperature at the motor, the ambient temperature should not exceed 40 C (104 F) for standard motors. If the ambient temperature does exceed this value, it may be necessary to use a special motor.

Both high and low ambient temperatures once presented problems in lubrication of instrument motors. Today, standard motor lubricants permit operation in ambient temperatures from −20 C (−4 F) to 40 C (104 F). Special lubricating oils are available for operation at lower and higher ambients.

Applications that require resistance to corrosive atmospheres, such as acid or salt, require special materials and finishes.

Weight and Space: Although weight and space are not major factors in selecting commercial instrument motors, the instrument or machine itself may sometimes limit either weight or space in one or more dimension. Weight is normally of interest only in portable instruments. Standard commercial motors are designed for an optimum combination of life, cost, and performance. Hence, size and weight of the motor are influenced by these other factors.

Shaft Coupling: Although shaft coupling normally does not present problems in instrument-motor application, there are cases where bearing and gear life, and instrument performance can be significantly affected. For example, is the shaft coupling to be direct or flexible? It is not wise to couple a gear motor directly when the instrument



1 Cross section of a typical synchronous or induction type motor designed with ball bearings.

repeatedly hits a stop because the life of the gears may be substantially reduced. A flexible coupling, on the other hand, minimizes the shock.

Life of the output bearing is affected by the nature of the load on the output shaft. When a spur gear is mounted on the output shaft, the shaft load is radial. With a helical gear or a worm gear the load is both radial and axial. Since radial loading can most seriously affect bearing life, every attempt must be made to minimize this type of shaft loading. Maximum allowable motor-shaft end play on a worm-gear application should be specified because end play could be sufficient to permit excessive shaft motion without any movement of the worm gear. This condition would cause the instrument to be out of calibration.

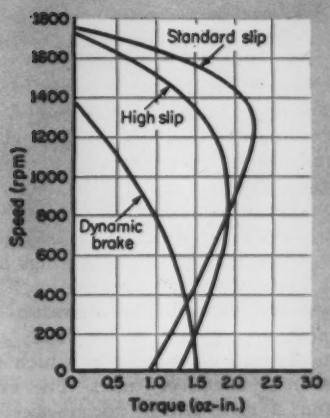
Noise: The normal sound level in a running instrument motor is usually so low that motor noise is of little concern. If the application is such that an exceptionally low sound level must be attained, such as in a dictating machine or tape recorder, the maximum sound level must be specified.

Gearing: Gear ratios available in instrument gear motors range from 2.5:1 to 3600:1 in over fifty successive steps. Gear trains in gear motors are totally enclosed as an integral part of the motor. Only the length of the motor is increased. The gear motor usually requires less space in both length and cross section than the combination of a direct-drive motor and external gearing. Except when produced in large volumes, the total cost of gearing and motor is also greater when the gears are made separately for external installation.

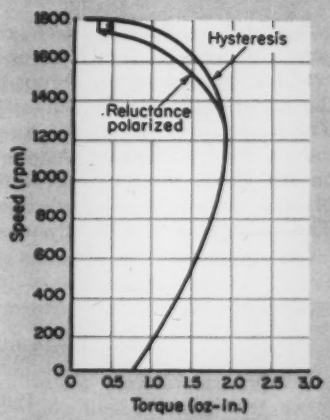
Commercial instrument gear motors have an output shaft backlash from ½ to 1 degree. Where less backlash is required, a special motor may be necessary.

Motor Types

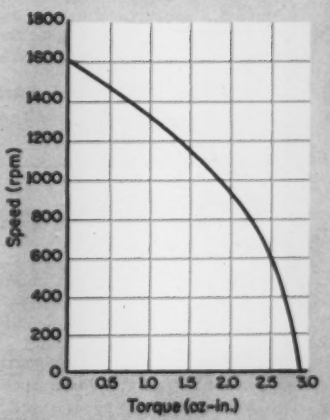
Three basic types of commercial instrument motors are synchronous, induction, and servo. The synchronous motors are divided into reluctance,



2 Typical speed-torque curves for induction motors. The standard slip curve is based on a 2 9/16-in. diameter design which develops a full-load torque of 0.3 oz-in. at rated speed of 1725 rpm.



3 Typical speed-torque curves for 1800-rpm synchronous motors. Rated full-load torque of 0.15 oz-in. is developed by a 10-watt, 2 9/16-in. diameter motor.



4 Typical performance curve for a 12-watt, 2 9/16-in. diameter servo motor. Rated speed is 1100 rpm and full-load torque is 0.75 oz-in.

hysteresis, and polarized electrical designs. Induction motors are designed for either standard or high slip and can be built for dynamic braking. All three basic types of motors have components and construction very much like the cross section of the synchronous or induction type in Fig. 1. All types are available with either ball bearings, as in the cross section, or sleeve bearings and as gear motors.

Table 2 summarizes for each type of motor its primary performance characteristic, nature of the most appropriate motor load, and typical instruments and equipment in which that type of motor is most effectively used. The curves in Fig. 2, 3, and 4 give typical torque-speed characteristics of representative instrument motors of each type. Many of the primary performance characteristics in column 2 of Table 2 can be seen by comparing the shapes of the performance curves.

Synchronous Motors: Both the reluctance and polarized types of synchronous motors in Fig. 3 are characterized by an abrupt change in speed as the motor shifts into or out of synchronous speed. The load inertia affects the torque at which these motors will synchronize. As shown by the arrows on the curve, the torque at which this shift takes place is slightly lower in starting than in stopping. The only difference in hysteresis motors is that the motor attains synchronous speed smoothly, and can be used to synchronize high-inertia loads with no effect on synchronizing torque. A synchronous motor may be dynamically braked by applying direct current across the winding. The dc power required for braking is usually about the same as the rated motor power.

Induction Motors: Slip in an induction motor is the percentage reduction in synchronous speed at rated load. Thus, in Fig. 2 standard slip is about 4 per cent below synchronous speed at rated load. The high-slip induction motor runs at about 1680 rpm at rated load—a slip of about 8 per cent. A typical instrument application of an induction motor is shown in Fig. 5.

The high starting torque and more linear speed-torque curve of the dynamic-brake motor more closely approximates the performance of a servo motor, Fig. 4. The dynamic-brake motor can have a higher block-start torque than either the standard-slip or high-slip type, and can be conveniently and instantaneously stopped by momentarily shorting the capacitor or by using direct current. Because of the small power dissipation of instrument motors while blocked (about the same as rated power), dynamic-brake motors are usually left on the line when stopped.

Table 2—Instrument-Motor Characteristics and Typical Applications

Motor Type	Performance Characteristics	Typical Applications	Nature of Motor Load
Synchronous			
Reluctance	Constant speed, moderate cost	Timing devices, switches, interruptors, chart drives	Continuous load within range of starting torque
Hysteresis	High starting torque, smooth starting	Tape drives (high inertia), recorders	High inertia
Polarized	Fixed mechanical position of shaft with respect to electrical input phase	Spectrophotometers, choppers	Chopping disc or commutator
Induction			
Standard slip	High speed	Blowers, business machines	Common power applications
High slip	High starting torque, low speed drop with torque increase	Dictating machines, other business equipment	Power with high load inertia
Dynamic brake	High starting torque, more linear speed-torque curve	Valve positioners, vending machines, instrument balancing	Frequent stop and start, and stop at an exact position
Servo	High torque-inertia ratio, linear speed-torque curve	Pen drive, any potentiometer balance use in process control	Two-phase intermittent duty (reference phase across line, control phase into amplifier)

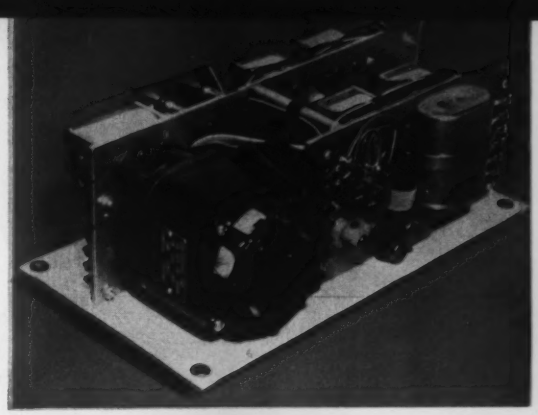
Servo Motors: The curve for the typical servo motor in Fig. 4 fulfills the major application requirements of a relatively high starting torque and a linear speed-torque curve. Most servo motors have very low rotor inertia, so that the high torque-to-inertia ratio permits extremely rapid starts, stops, and reversals, Fig. 6.

▶ Motor Selection

The selection of the optimum instrument motor for any given application depends on careful matching of application requirements with motor performance data. The following sequence is recommended:

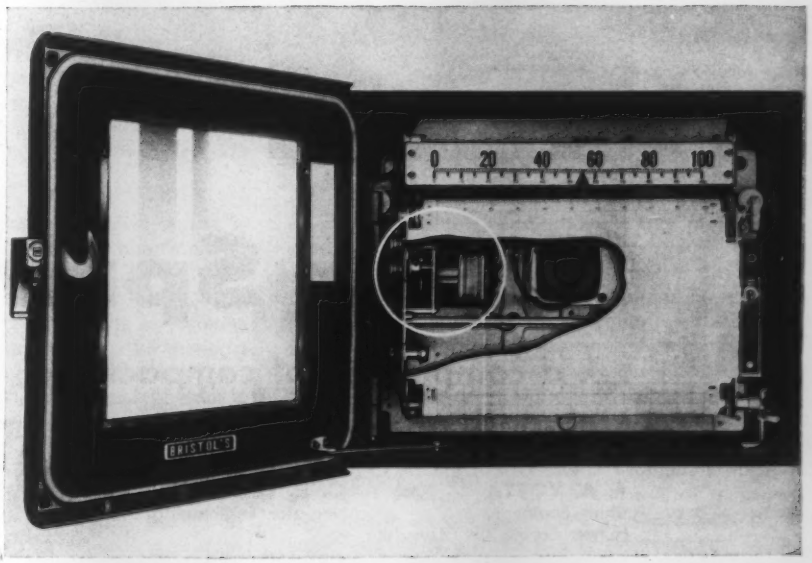
1. Determine all pertinent performance requirements and operating conditions. Then, select the type of instrument motor which best matches the type of application from Table 1 and the load from Table 2.
2. Review catalog data for the type of motor selected to find the specific motor which delivers the required performance under the given operating conditions.
3. If there is no obvious standard motor which will do the job, ask for a special motor. A special motor may involve only a minor change in a standard model or a completely new—and costly—construction.

Standard or Special: Wherever possible, a standard motor should be selected to obtain the advantages of lower cost, prompt delivery, and convenient replacement. Unique performance requirements, such as a high intermittent torque or an unavailable gear ratio, may require a special motor. Operating conditions for which a special motor may be justified include cases where there is either no other way to accomplish the job or when the additional cost of the special motor is less than the amount it saves in the design of associated components. When a contemplated special motor is excessively expensive, it is often possible to change performance requirements slightly to permit use of a slightly modified standard motor.

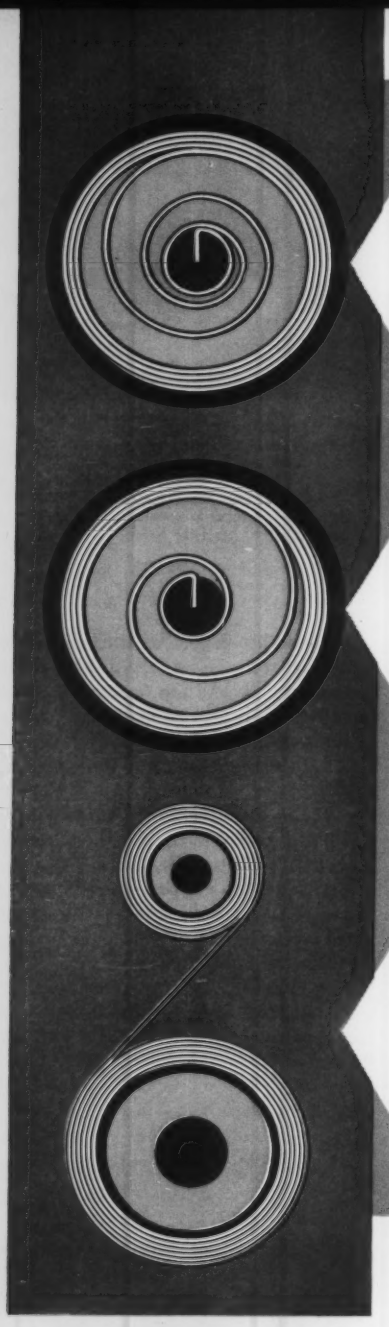


5 Standard 2 7/8-in. induction motor designed with a special end cap to simplify mounting. Applied in a tape perforator manufactured by Precision Specialties Inc., the motor drives a spring-capstan clutch which is started and stopped at high speed by a solenoid-operated latch. The motor must maintain speed during clutching from no load to full load.

Value Analysis: Particularly in large-volume applications, cost is naturally a major consideration in evaluating alternate possibilities in standard instrument models or types as well as special motors. Value analysis in making such decisions should involve the relative cost of the motors as installed—unit motor cost plus assembly rather than the cost of the motor alone. If equivalent performance capability is assumed, it is possible that a higher-cost motor can result in a lower over-all instrument cost.



6 Servo motor with a high torque-to-inertia ratio can drive the inking pen and pointer the full width of the chart in 0.4 sec in this Bristol recorder. The 2 ½-in. diameter motor is built with a special winding to match amplifier output.



Oldest strong man of the motor-spring clan is the familiar mainspring or power spring.

A younger brother is even stronger. Capitalizing fully on residual stresses from prestressing, this new spiral spring provides more useful output energy.

Cousins are the noncumulative-force springs. They release the most useful energy and can claim constant torque output.

Motor Springs

. . . a comparison of compact, high-deflection, spring-energy sources

F. A. VOTTA and **C. R. LEIDIGH**
Chief Engineer — Neg'ator Engineering Div.
Hunter Spring Co., Lansdale, Pa.

COMPACT and convenient to use, spring motors deliver controllable torque where other energy forms are unavailable or poorly regulated, or where other types of motors are too expensive, complicated, or heavy.

Since all springs are capable of releasing stored energy in the form of work, it is conceivable all could be classed as motor springs. Here, however, motor springs are defined as elastic members capable of the storage and controlled release of rotational energy through a number of turns. This definition rules out both helical and stiff, open-wound spiral torsion springs, which operate through limited angular deflection. The long helical torsion spring, which can deliver several turns of torque and is occasionally used as a motor spring, is not discussed either. Its application is limited and often dictated by rather unusual space requirements.

Spiral Springs

The oldest and most common motor spring is the close-wound, flat spiral spring. Known as a clock spring, a power spring, or a mainspring, Fig. 1, it was invented almost 500 years ago for clocks. The spiral power spring is a strip of spring-tempered material wound on an arbor and restrained within a circular ring or cylindrical case. Its inner end is fastened to the arbor, while its outer end is fixed to the restraining device.

The power spring stores rotational energy by being stressed in pure bending. At full wind, all of the material except the extreme outer end is coiled tightly about the arbor, and each coil is in contact with adjacent coils. When the arbor or restraining ring is released to rotate, all of the coils expand to seek their condition of minimum curvature and stress. The spring delivers a moment about the arbor until it reaches the maximum expansion allowed by the restraining ring. When completely run-down, the spring, except the extreme inner end, is coiled solidly at the maximum radius allowed by the keeper.

Advantages and Limitations: The spiral spring is a relatively inexpensive, compact mechanism. Its over-all cylindrical conformation and its rotation about a single axis make it convenient to use.

Since the stress build-up in the spring is cumulative, so is energy storage. As a result, the moment delivered by the spring decreases throughout unwinding from a maximum at the instant of release to zero at full run-down, Fig 1.

This output characteristic may be desirable in some applications. The spring can be adjusted to deliver a particular moment at a certain position.

If minimum torque output is required, the power spring can produce that output at only one condition of wind. At all other times the torque must be either too great or too small. Energy available at the lower torque outputs may have to be discarded, because it is either insufficient for the application or because excessive intercoil friction prevents the spring from delivering it reliably.

All associated components—transmission elements, escapements, governors, controls—must be designed strong enough to withstand the high peak torque near full wind. If a relatively constant speed is desired to drive a mechanism, the high torque compli-

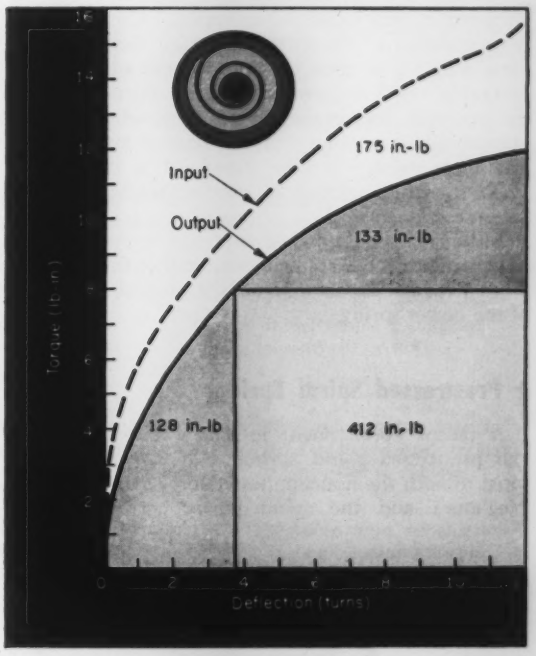


Fig. 1—Input and output curves of a conventional spiral power spring. Useful-energy rectangle is determined as the rectangle of maximum area—maximum product of torque and turns. Of the 840 in.-lb of input energy, a maximum of 49 per cent is useful at minimum torque of 8 lb-in. for 8¼ turns (66 lb-in.-turns).

cates the governing, and stored energy must be dissipated.

If both high and low extremes must be ignored, efficiency and number of turns available are reduced. One way to increase the number of turns is to lengthen the spring and use thinner stock. However, intercoil friction is always increased when either length is increased or material thickness is reduced.

The practical limit of the length-to-thickness ratio is about 15,000.

Few spiral springs operate through more than 20 useful revolutions. Fifteen turns is often considered the more practical limit. If the driven mechanism must operate through many more revolutions

than the spring, gearing is necessary.

In spiral power springs designed to deliver the maximum possible number of turns, intercoil friction may interfere with the smooth run-down of the spring. The longer and thinner the spring, the more pronounced is this jump action. Power springs should be lubricated to minimize the tendency of the spring to hang-up.

Efficiency: The useful fraction of total input energy available from a power spring is low—sometimes less than 50 per cent, Fig. 1.

Number of turns at high torque is also limited. Motor-drive applications often require more output energy than a power spring can provide at the minimum required torque level. The answer then is to use a higher output torque and gain turns with gearing.

Several methods are available for improving the efficiency of the spiral power spring. Most common is prestressing of the spring material, such as by reverse winding or cross curving, to take advantage of favorable residual stresses. Fiber stresses, set into the material, oppose the stresses imposed during operation. Thus, higher working stresses may be used and more energy can be stored. Use of crowned stock to reduce friction is another method used to increase efficiency.

Although the improvements are noticeable and important in some applications, neither method provides a radical departure from the normal limitations of the power spring.

▶ Prestressed Spiral Springs

A recent development in spring motor drives is the prestressed spiral spring, Fig. 2, which is related to both the noncumulative-force spring (termed Neg'ator) and the spiral power spring. Trademarked Spir'ator, it resembles the spiral power spring in appearance and operation, but its forming process derives from the development of the Neg'ator spring.

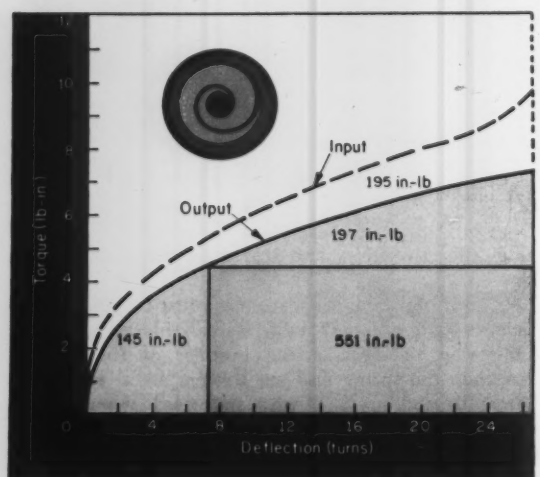


Fig. 2—Input and output curves of a prestressed (Spir'ator) spring of the same weight as the power spring in Fig. 1. Of the 1088 in.-lb of input energy, a maximum of 51 per cent is useful at minimum torque of 4.4-in. for 20 turns (88 lb-in.-turns).

Instead of being prestressed to form a reverse spiral, the Spir'ator spring is initially prestressed to form a tight coil. Residual stresses introduced into each increment of length are equal. Thus the outer coil is as heavily stressed as the inner coil.

The outer end of the original tight coil is reverse bent and fastened to the arbor; the inner end is secured to the case. The high initial stress produced by forcing the already uniformly heavily stressed material inside out provides a high resisting moment at the start of winding. As angular deflection progresses during winding, stress and torque throughout all the material increase gradually.

The residual stresses permit higher working stresses and, in turn, thinner material and greater length in the same case size. Also, the inherent outward thrust of the material causes a greater proportion of the length to be active throughout deflection.

Advantages and Limitations: Like the spiral power spring, the Spir'ator spring is a compact, single-axis mechanism. However, because it utilizes the material at a higher stress level, it develops more of the energy-storage potential of the material, Fig. 2, for a given life requirement.

Intercoil friction is always present. Depending upon design proportions, jerky action may occur. Generally, lubrication is advisable.

Outstanding application characteristic of the prestressed spring is its ability to sustain delivery of useful torque through many turns, Fig. 2.

Conversely, it is not as well-suited to applications where a widely adjustable output is desired, because the narrow range of torque variation ceases to be a great advantage.

Motors capable of producing as many as 50 turns have been successfully designed. No maximum length-to-thickness ratio has yet been established. Experience indicates that satisfactory operation can be attained with length-to-thickness ratios in excess of 15,000. Since a longer spring capable of producing a greater proportion of useful torque can be used, lower gear ratios and lighter-duty parts are possible than with a comparable spiral spring.

Efficiency: Comparing Fig. 1 and 2 shows that the new prestressed spring is only slightly more efficient than the conventional power spring—output compared to input. However, for the same weight of material, it produces more total useful energy. Thus, it is much more efficient in terms of useful energy compared to energy potential of the material.

Fatigue Life: Maximum stress and operating-stress range are the primary influences on the fatigue life of a motor spring. When compared to those of a conventional power spring, the working stresses of the Spir'ator spring are very high. However, the operating-stress range is much less than that of the most highly stressed portion of a cumulatively

Comparison of Motor Springs

	Spiral	Prestressed Spiral	Noncumulative Force
	Physical Characteristics		
Mounting	On a single arbor with restraining ring or case.	Same as spiral spring.	On two spindles: one output, one take-up.
Relaxed Configuration	Open coil to allow for winding.	Same as spiral spring.	Tightly coiled spiral on take-up spool.
Wound Configuration	Tight coil on arbor.	Same as spiral spring.	Tightly coiled on output drum.
Number of Rotations	Seldom greater than 15.	Readily, 20 turns. As many as 50 turns possible at reduced energy storage efficiency.	Limited only by space available (100 turns present practical limit).
Forming Process	Wound directly on arbor, or some reverse winding of longer springs.	Prestressed through sequential bending and thermal processing.	Special sequence of preforming and thermal processing.
	Performance		
Charging	Stressed cumulatively as a unit by winding to a tight spiral.	Same as spiral spring.	Stressed uniformly.
Useful Energy Storage	Limited by number of effective revolutions, moderate nonuniform working stresses.	More useful energy because of high working stresses.	Highest energy storage because of higher working stresses, nearly uniform stress distribution throughout material.
Torque Output	Optimum value available only momentarily. Diminishes rapidly from maximum throughout cycle.	Diminishes on delivery stroke less rapidly than power spring from a beginning maximum.	Initial torque maintained throughout cycle.*
Efficiency	Energy wasted by friction and in compensating for nonuniform rate of release.	Same as spiral spring except lower percentage of input energy need usually be wasted.	Negligible friction loss and little energy wasted because it is released at uniform rate.*
Input Torque	Effort increases during winding. Torque input required to fully wind reaches a high peak.	Effort also increases but less rapidly. Lower input required to fully wind.	Winding effort remains low because restraining torque does not build-up.*
	Application Characteristics		
As a Drive Unit	Limited number of turns. Gearing usually required.	More turns usually possible. Reduction in associated gearing possible.	Greatest number of turns. Sometimes applied without gearing.
To Deliver Linear Force	Requires gearing and linkage to provide linear displacement.	Can provide longer linear displacement, with less linkage than power spring.	Large number of turns available for conversion to long-displacement linear force.
Adjustability	Wide output torque range available for output adjustment.	Narrow output torque range available for adjustment.	Output nonadjustable once mounted.*
Associated Components	Must be able to handle high maximum output torque.	Lower maximum torque allows use of lighter duty parts.	Constant output allows use of light-duty parts.*
Output Control	Governor escapement must operate over wide torque range.	Governor operates over narrower torque range.	Governor required only for very close control.

*For constant-torque B motor. Low-gradient B motor produces slightly excess torque which decreases gradually at a constant rate during rundown.

stressed power spring. Therefore, the two factors tend to compensate for each other, and life characteristics of the two types of spring are similar.

▶ Noncumulative-Force Springs

Introduced in 1949, the noncumulative-force spring —trademarked Neg'ator—is dissimilar in appearance and operation from spiral springs. It is a strip of spring material which has been given a curvature by continuous heavy forming and thermal processing so that in its relaxed condition it takes the form of a tightly wound spiral. It stores energy by resisting the withdrawal of material from the tight spiral.

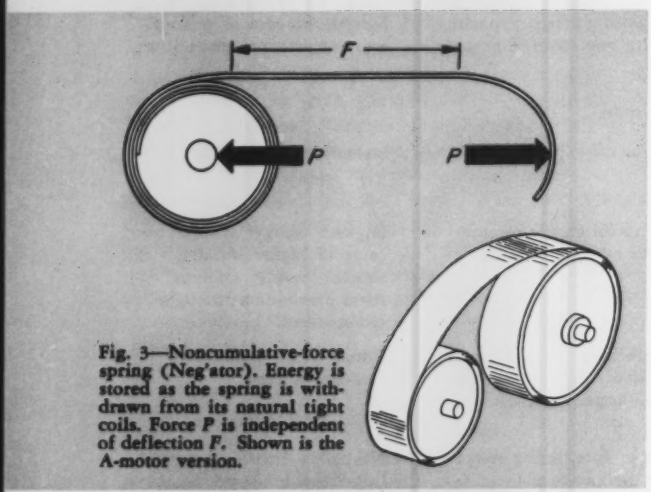


Fig. 3—Noncumulative-force spring (Neg'ator). Energy is stored as the spring is withdrawn from its natural tight coils. Force *P* is independent of deflection *F*. Shown is the A-motor version.

As shown in Fig. 3, when mounted for free rotation the material resists withdrawal from the coil with force *P* that is constant regardless of extension length *F*. The restraining force depends only upon the work required to deflect the material from the preset curvature. Thus, as long as each incremental length of the spring undergoes an equal increase in stress as it is straightened, the force which the spring exerts remains constant.

Type A: The Neg'ator spring itself delivers force linearly, in contrast to a spiral spring which produces a torque moment directly. However, because of its great length and flexibility, it is well suited for imparting a linear force at the periphery of a drum to produce rotation about the drum axis, Fig. 3. This arrangement is called a type A motor.

This mounting is equivalent to two Neg'ator extension springs opposing each other. The spring on the larger drum is weaker than that on the smaller drum because the curved material on the larger drum is over-expanded. The force exerted by the smaller coil overcomes that exerted by the larger, withdrawing the material from the larger drum and imparting rotation to it.

Type B: A more powerful and efficient drive is the type B motor, Fig. 4. As in the A motor, the material is mounted on, but usually not fixed to, a smaller take-up spool which is allowed to rotate freely. The outer end of the spring is extended and anchored to a larger output spool. To charge the unit, the output spool is rotated to withdraw the spring material from the smaller spool. However in the B motor the material is coiled about the larger spool counter to its normal curvature. Thus, in being transferred from the take-up spool, the material is first straightened, then bent backwards about the output spool.

When all of the material has been withdrawn from the take-up spool and reverse coiled about the output spool (in practice several turns are usually left on the smaller spool) the unit is fully charged. Release of the output spool allows the material to revert to its natural prestressed curvature by returning to the smaller spool, thereby imparting rotation to the output drum.

The material undergoes no change in stress while it is coiled upon either spool. In fact, whatever portion is coiled upon the take-up spool at any time is at virtually zero working stress. The material undergoes change in stress only as it passes from spool to spool. Thus the entire length of the spring is stressed during winding or unwinding in a truly noncumulative manner. The torque produced by

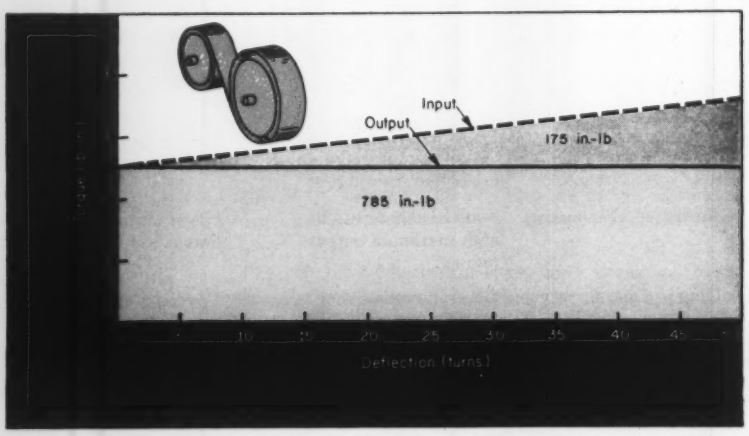


Fig. 4—Input and output curves of a B-type motor of the same weight as the spiral springs in Fig. 1 and 2. Of the 960 in.-lb of input energy, 80 per cent is useful at a constant torque of 2.5-lb-in. for 50 turns (125 lb-in.-turns).

the motor about the output axis can be almost perfectly constant from start to finish.

The torque results from two actions: The pull of the extended spring about the periphery of the output drum and the moment required to backbend the straightened section to conform to the curvature of the output drum. Output torque depends upon material width and thickness. However, angular displacement, the other factor which determines work performed, depends simply on the length of material which is limited only by the space available.

To actually produce a B motor providing a constant output moment, it is necessary to vary the incremental stresses introduced during forming so that force exerted at the periphery of the output coil will increase during run-down, to compensate for the constantly decreasing diameter, or lever arm. Uniform maximum stressing of each increment of length produces the most efficient B motor, but then output torque gradually decreases at a constant rate.

Since there is no relative motion between adjacent coils the friction losses in a B motor are in the bearings only.

Advantages and Limitations: The major operating advantage offered by this two-spindle spring motor is its ability to deliver nearly constant output torque over a large number of turns. This combination often permits design of a spring motor which can supply the required torque for the desired number of turns directly to the driven device without intermediate gearing, and with freedom from jumping or skipping action.

Practical limit on the number of revolutions for producing maximum work at constant torque with a Neg'ator B motor is about 60 turns. If a slight linear output gradient can be accommodated, B motors can deliver up to 100 turns.

Perhaps the most startling effect of its extremely long deflection, Fig. 4, is the large amount of useful energy which the Neg'ator B motor can thus provide. In many instances the spring can be designed to deliver the exact number of turns available. Thus gearing can be eliminated or reduced and all gears, governors and other associated components can be designed down, since they need not sustain excessive torques.

The constant torque output or low linear gradient of the B motor allows easy control of output. Occasionally this constant-torque performance is misinterpreted as a constant-speed property. Of course, this is not so. A governing device is still necessary to achieve constant speed. But the level torque output of the B motor greatly reduces the complexity of this mechanical requirement.

Also, the motor is easy to wind. Although the actual working torque resists winding immediately, and may increase slightly during charging, it does not suddenly build up a high resistance near the end of the charging operation.

Lack of intercoil friction eliminates any necessity for lubrication. Thus the problems of intermittent power delivery, encasement of the motor, sluggish low-temperature operation, and periodic maintenance are avoided.

If zero-gradient output is required, the relationship between the size of the drums and the outside diameter of the material coils must fall within a certain range. Reduction in lever arm as the material pays off the output spool must not be so great that it cannot be compensated for in the manufacture of the spring without seriously reducing its efficiency.

However, if a low output gradient is acceptable, the effect of the space limitation on total deflection is reduced. Therefore, unless there is some over-riding reason for requiring constant output moment, optimum B-motor design to produce maximum total energy in a given space should be considered.

Because of the exceptionally high, repetitious operating stresses, fatigue is an important consideration in B-motor application, and imposes a major application limitation. Therefore, a well-conceived idea of the required number of operations is almost mandatory for successful application. Underestimation of life requirements will compromise reliability while overestimation will often create excessive space requirements and increase cost.

Space required may be a limiting feature of the Neg'ator spring in some applications. Configuration required with two spindles may be more inconvenient than uniaxial spiral springs. This limitation is often mitigated by two factors: 1. Volume of spring material for required useful energy is less than for spiral springs. 2. The spindles may often be concentric with other required elements of the mechanism being driven.

Energy comparison for the three types of motor springs is summarized in Fig. 5.

A future article will discuss design details and procedures for motor springs.

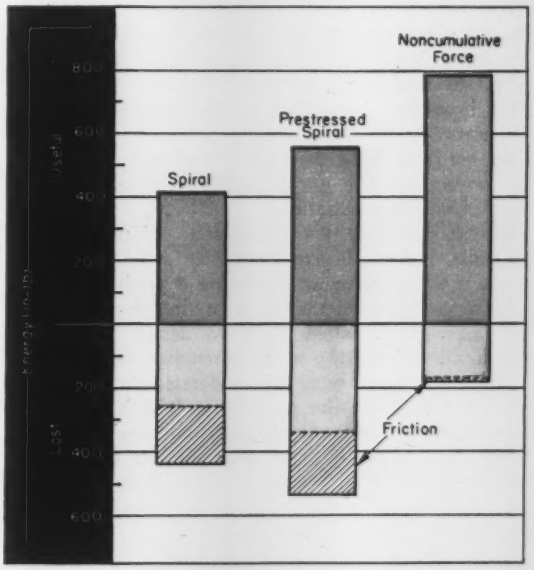


Fig. 5—Energy comparison of three types of motor springs having the same weight of material.

The Personal Side of Engineering

EDWIN C. NEVIS Personnel Research and Development Corp., Cleveland, Ohio

Adjusting to Design Compromises

ALMOST daily, every design engineer is called upon to make compromises. His attitude toward them, and the way he responds to demands for compromise, bear strongly upon an engineer's job satisfaction—and upon his effectiveness in the eyes of his employer.

Many design engineers are continually frustrated or unhappy because of difficulty in resolving the ethical and practical problems presented by compromise situations.

One of the paramount reasons is that such demands challenge one of the basic values of the engineer. Because of his professional training and his system of ethics, the design engineer believes that his task is to develop the *best* solution to a technical problem—that technology should be utilized to achieve top-quality performance. This value is challenged most often by two kinds of manufacturing and sales demands.

The first is the need to cut costs so that products can be manufactured at competitive prices. In this type of compromise, the design engineer is often required to modify a technically "perfect" product to bring it within a specified production cost. Though engineers are basically very practical in their outlook, conflicts arise because of reluctance to mar the perfection of a design solution to satisfy some nontechnical consideration.

The second type of compromise, and perhaps the one most threatening to the ethical values of engineers, is the problem of designing a product to conform to consumer demands or styling desires. Here, the engineer is called upon to design a product which will be pleasing to the consumer, even though it may not agree with his understanding of what is needed to make the product do its job. A typical problem here is the use of ornamentation and decorative "gimmicks" to dress up a product that would function equally well without them. Related to this type of problem is the controversial question of designing for "planned obsolescence."

Although a design engineer may exert a great deal of influence to lessen or eliminate these compromises, he is often faced with an issue well beyond his immediate control. The social and economic values of our culture are certainly formidable foes for the engineer to take arms against. But, each engineer must come to grips with these problems if he is to feel comfortable and, hence, be productive in his work.

Some engineers solve the problem by a kind of psychological blindness in which they resolve not to become involved with the issue at all. Such an attitude, for example, is to accept the demands uncomplainingly, shrug one's shoulders and say, "I only work here." Though short-term performance may not be affected, an apathetic and passive attitude eventually develops which affects both morale and productivity.

At the other extreme, an engineer might take a stubborn, rebellious attitude in which he fights to the last inch and never gives in unless he is almost "beaten" into submission. This, too, is an unsuccessful resolution, for it results in frustration and tension. Engineers of this type are typically poor job-tenure risks. They are always searching for a greener pasture where they presumably do not have to make such compromises.

It is difficult to spell out a psychologically and practically effective middle ground. Perhaps the mature attitude is to make a firm statement of one's views, but modify them as compelled by outside forces. Adjustment to demands for compromise is also helped by analyzing the reasons for the demand. This does not mean giving in without a fight for what one believes in, but rather for seeking some understanding of the real issues in a compromise situation. If he is to deal with a compromise situation in a mature manner, each engineer needs to evaluate just what is expected of him and what he can expect.

Though it is often overlooked, the engineer who desires job satisfaction might well ask himself, at the time of seeking employment, what kinds of compromises he will have to make in the new job. Ability to "live with" compromise demands is as essential to personal success and happiness in a design job as the working out of the technically best solution.

A simplified step-by-step procedure for rapid design of

Round-Section Beams

CHARLES W. BERT
Principal Mechanical Engineer
Applied Mechanics Div.
Battelle Memorial Institute
Columbus, Ohio

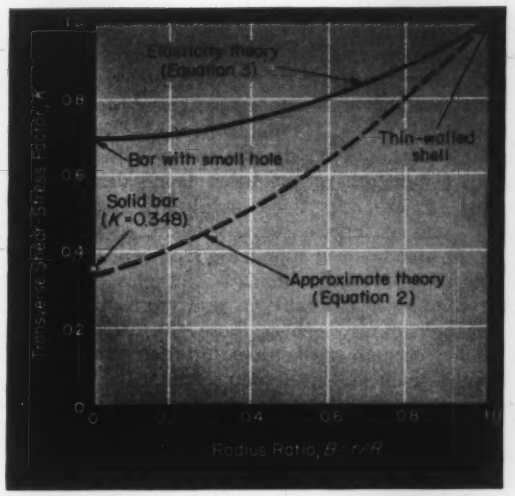


Fig. 1—Transverse shear-stress factor K plotted as a function of radius ratio B for solid and hollow round-section beams. Solid curve, which represents elasticity-theory solution, is recommended for conservative design. Dashed curve represents approximate theory.

Nomenclature

a, b = Beam dimensions, in.
B = Radius ratio
$= r/R$
C = Strength constant
I = Moment of inertia of beam cross section about neutral axis, in.^{4}
$= \pi(R^4 - r^4)/4$
K = Transverse-shear stress factor
L = Effective beam length, in.
$= M/V$
M = Maximum bending moment, lb-in.
M_0 = Applied moment, lb-in.
P = Applied load, lb
R, r = Outside and inside radii, respectively, of beam cross section, in.
S_b = Maximum bending stress, psi
S_e = Equivalent tensile stress, psi
S_s = Maximum transverse-shear stress, psi
V = Maximum shear load, lb
w = Uniformly distributed load, lb per in.
ν = Poisson's ratio

BEAMS are subject to two stress conditions: Bending and shear. The extent to which each stress influences design depends on the effective beam length.

Most design problems involve "long" beam members in which bending stresses are of primary concern. However, in "short" beams, such as stub axles and lugs, transverse shear stress may be the controlling consideration.

In this article, attention is focused on the application of bars and tubes of circular cross section as beam members. A general design procedure and basic concepts are presented along with simplified criteria for determining whether a beam is long or short.

Stress Analysis: Maximum shear stress S_s developed by bending in a round-tube beam occurs at the neutral axis and is given by (see Nomenclature)

$$S_s = \frac{KVR^2}{I} \qquad (1)$$

where values of K, plotted as a function of radius ratio B, are given for two theories of transverse shear stress in Fig. 1. The lower dashed curve is based on a well-established approximate theory where

$$K = \frac{1 + B + B^2}{3} \qquad (2)$$

The upper curve, Fig. 1, is based on the elasticity-theory solution[1] and represents a plot of

$$K = \frac{3 + 2\nu + (1 + 2\nu)B^2}{4(1 + \nu)} \qquad (3)$$

where $\nu = 0.285$ (steel). Since a change in ν has little effect on the value of K, this curve can be used for materials which have Poisson's ratios ranging from $\nu = 0.25$ to 0.45 without more than 3½ per cent error.

Equation 1 can also be used to determine maximum shear stress in a solid bar subjected to bending[1] where K is

$$K = \frac{3 + 2\nu}{8(1 + \nu)} \qquad (4)$$

For steel with $\nu = 0.285$, Equation 4 gives $K = 0.348$.

As shown by comparison of the two curves, Fig. 1, maximum discrepancy in the two theories occurs as B approaches zero and the hole at center of the tube becomes infinitesimal. Neither the approximate

[1]References are tabulated at end of article.

nor elasticity theories is completely reliable at this extreme condition and actual stress values may fall somewhere between those given by the two solutions at low values of B.

For conservative design, use of the upper plot in Fig. 1 (elasticity theory) is recommended for tubular sections. A value of $K = 0.348$ is recommended for solid bars.

Design Criteria: Before a part can be adequately designed to resist failure, the most critically loaded point must be determined by analysis of component stresses in the stress system. In a round-section beam, the transverse shear stress, as given by either the approximate or elasticity theories, is a maximum at the neutral axis and zero at the outer fiber. Bending stress, given by the conventional beam formula, has a maximum tension value on one side of the beam, a maximum compression value on the opposite side, and is zero at the neutral axis. Maximum tensile bending-stress in a round-section beam is found from

$$S_b = \frac{MR}{I} \tag{5}$$

Various strength criteria are used in design to predict behavior of a part under load.[3]

The most widely accepted strength criteria today are:

1. Yield criterion.
2. Maximum shear-stress criterion.
3. Maximum normal-stress criterion.

The yield criterion is currently used to define yielding. The maximum shear-stress criterion gives the best agreement with test results for ultimate failure of ductile materials which have the same ultimate strengths in tension and compression. The maximum normal-stress criterion is often used for brittle materials and for ductile materials which have appreciably different ultimate strengths in tension and compression.

Each of these criteria provide a basis for determination of an equivalent tensile stress, S_e. This equivalent stress is defined as the ordinary tensile-test value of stress that is equivalent, so far as failure is concerned, to the stress system acting on the most critically loaded point in the actual part. For each of the strength criteria, the equivalent stress may be expressed as a function of the bending and shear stresses in a beam.

For the yield criterion,

$$S_e = (S_b^2 + 3S_s^2)^{1/2} \tag{6}$$

For the maximum shear-stress criterion,

$$S_e = (S_b^2 + 4S_s^2)^{1/2} \tag{7}$$

For the maximum normal-stress criterion,

$$S_e = \frac{S_b}{2} + \left(\frac{S_b^2}{4} + S_s^2 \right)^{1/2} \tag{8}$$

According to each of the three strength criteria, maximum equivalent stress in a round tube or bar always occurs at either the neutral axis or the outer fiber. Thus, intermediate points in the cross section need not be considered in determining the most critically loaded point of a part.

At the neutral axis, there is no bending stress. Hence, when $S_b = 0$, Equations 6, 7, and 8 are reduced to $S_e = CS_s$, where C is a "strength constant" with values of 1.732 for the yield criterion, 2 for the maximum shear-stress criterion, and 1 for the maximum normal-stress criterion.

At the outer fiber, there is no shear stress. Hence, when $S_s = 0$, Equations 6, 7, and 8 reduce to the same equality, $S_e = S_b$.

A useful index for the analysis of beam geometry is the effective length, L, which is defined as the maximum bending moment divided by the maximum shear load, $L = M/V$.

Thus, for a simple cantilever beam with concentrated end load P, $V = P$ and $M = PL$, where effective length L is the actual length. Equations for calculating V and L for various simple conditions of beam loading and support are given in Table 1.

Values used for M and V in effective-length calculations should be the maximum values occurring in the length of the beam being designed or checked for strength. If M and V are known, this concept may be applied to any beam, regardless of where M and V occur along the length of the beam section under consideration.

For complex load conditions that are combinations of simple loadings, such as those given in Table 1, particular care must be taken in determining the maximum shear and maximum moment for the combination. For example, except for the special case in which the maximum moment occurs at the same point for each separate component load, the maximum moment for a combination load system will not be equal to the sum of maximum moments for the component loads.

Another useful tool in the design of round-section beams is the transitional value of L/R. It is defined as the ratio of effective length to outside radius at any point along the beam where the maximum equivalent stress along the neutral axis is equal to the maximum equivalent stress at the outer fiber. Thus, long beams have an actual L/R ratio greater than the transitional value, intermediate beams have an actual ratio equal to the transitional value, and short beams have an actual ratio less than the transitional value. The transitional value of L/R, $(L/R)_t$, is determined by equating the expressions for the equivalent stresses at the two points and by solving for L/R:

$$\left(\frac{L}{R} \right)_t = CK \tag{9}$$

Thus, to determine the transitional value of L/R, K from Fig. 1 is multiplied by the strength constant, C, corresponding to the strength criterion selected as the basis for design.

Design Procedure: The following step-by-step procedure, based on the criteria presented previously,

is recommended for design of round-section beams.

1. Determine maximum shear load V and effective length L. Use Table 1 or $L = M/V$.
2. Determine actual L/R value.
3. Determine radius ratio $B = r/R$.
4. Select a strength criterion for design based on the type of failure and class of material.
5. Find value of K. For tubular beams, use upper plot in Fig. 1; for solid bars, use $K = 0.348$.
6. Calculate transitional value of L/R from Equation 9.
7. Calculate maximum equivalent stress. If the actual L/R value (step 2) is greater than the transitional value (step 4), the member is a long beam and the maximum equivalent stress, which equals the maximum bending stress, is

$$S_e = \frac{VLR}{I} \qquad (10)$$

If the actual L/R value is less than the transitional value, the member is a short beam and the maximum equivalent stress is

$$S_e = \frac{CKVR^2}{I} \qquad (11)$$

For intermediate length members, either solution may be used for equivalent-stress determinations.

Strength-Check Example: Find the factor of safety, based on failure by yielding, for a simply supported hollow axle which carries a centrally located concentrated load, $P = 30{,}000$ lb. Tensile yield strength of the axle material is 125,000 psi. Axle dimensions are: $r = 0.75$ in., $R = 1$ in., and total length $= 2$ in. Moment of inertia $I = 0.537$ in.^{4}

This load condition is covered by Case 7 in Table 1 with $a = b$. From Table 1, maximum shear load $V = [1/(1+1)]\ 30{,}000 = 15{,}000$ lb and effective length $L = 1$ in.

Actual L/R value $= 1/1 = 1$ and radius ratio $B = 0.75/1 = 0.75$.

The yield criterion will be used here with $C = 1.732$.

From Fig. 1 at $B = 0.75$, $K = 0.87$. From Equation 9, $(L/R)_t = 1.732\ (0.87) = 1.51$.

Since the actual L/R value is less than the transitional value, this member is a short beam. Hence, from Equation 11,

$$S_e = \frac{1.732(0.87)\,(15{,}000)\,(1)^2}{0.537} = 42{,}000 \text{ psi}$$

Factor of safety is $125{,}000/42{,}000 = 2.97$.

Beam-Design Example: Find the required diameter of a solid steel cantilever lug or stud which is 1 in. long and carries a concentrated end load, $P = 30{,}000$ lb. Design is to be based on an equivalent stress of $S_e = 30{,}000$ psi which includes an allowance for a factor of safety.

This simple cantilever arrangement is covered by Case 1 in Table 1. Maximum shear load $V = 30{,}000$ lb and effective length $L = 1$ in.

Since the ultimate tensile and compressive strengths of steel are approximately equal, the maximum shear-stress criterion will be used as a basis for design. Thus, strength constant $C = 2.0$.

For a solid bar, $K = 0.348$. From Equation 9, $(L/R)_t = 2(0.348) = 0.696$. At this transitional value, $R = 1/0.696 = 1.44$ in. If the actual R is less than 1.44 in., the member is a long beam and, from Equation 10,

$$S_e = \frac{4VL}{\pi R^3}$$

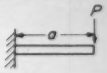
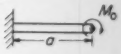
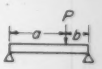
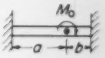
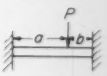
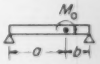
Solving this expression for R,

$$R = \left(\frac{4VL}{\pi S_e}\right)^{1/3} = \left[\frac{4(30{,}000)\,(1)}{3.14(30{,}000)}\right]^{1/3} = 1.08 \text{ in.}$$

Since this value of R is less than the transitional value, it is the correct solution. The required diameter is $2R = 2.16$ in.

If radius R is solved on the basis of a short-beam condition (Equation 11), a value less than the transitional value is obtained. This solution contradicts the theoretical relationship and, thus, is incorrect.

Table 1—Relationships for Shear-Load and Effective-Length Calculations

Load Condition		Shear Load, V	Effective Length, L
Case 1		P	a
Case 2		wa	$\frac{a}{2}$
Case 3		No shear. Design for bending moment M_0 only	
Case 4		$P\frac{a^3+3a^2b}{(a+b)^3}$	$\frac{2b^2}{a+3b}$ $(a \geqq b)$
Case 5		$\frac{wa}{2}$	$\frac{a}{6}$
Case 6		$\frac{6M_0ab}{(a+b)^3}$	$4b - a + \frac{a^2}{b}$ $(a \geqq b)$
Case 7		$P\frac{a}{a+b}$	b $(a \geqq b)$
Case 8		$\frac{wa}{2}$	$\frac{a}{4}$
Case 9		$\frac{M_0}{a+b}$	a $(a \geqq b)$

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Design and Application of

Belt, Chain, and Gear Drives

E. S. CHEANEY, C. L. PAULLUS, and W. C. RARIDAN
Battelle Memorial Institute
Columbus, Ohio

FOUR types of belt drives that handle the bulk of power being transmitted through belting are shown in Fig. 1. Load-carrying ability and life of V and flat belts have been enhanced by improved materials, and the range of power coverage is being extended. Addition of a plastic inner ply in one type of flat belting has resulted in marked improvements. The ribbed belt is the successful result of efforts to combine the strength and simplicity of the flat belt with the high grip and positive groove-tracking of the V-belt.

The toothed belt has rapidly found wide acceptance because of its positive drive and high-speed ratings. The readiness with which wide-section V-belts can be adapted to infinitely variable speed drives has led to many machines which embody this feature. A recent interesting application of variable-speed V-belts is in the transmission of the DAF automobile manufactured in Holland.

Chains: Fig. 2 illustrates the many types of chains developed over the years to fill a wide range of requirements. Chains are now available in a variety of materials, such as stainless steel, which meet requirements of high temperatures, corrosion resistance, and other special environmental conditions. A recent innovation is the development of bead chain, Fig. 2*e*, as a power-transmitting device for low speed and power. Bead chains are versatile with respect to shaft alignment, and can be operated on shafts which have been skewed as much as 90 deg. Bead chain can also drive intersecting shafts up to an included angle of 40 deg.

Another recent development is an inverted-tooth silent chain, Fig. 2*d*, which has a rocker joint at the point of articulation. Design of the rocker joint is such that chordal action is eliminated so that the uniform motion is imparted to the driven sprocket. A unique chain drive which is available is the infinitely variable silent chain drive shown in Fig. 2*f*. This drive embodies a tooth-forming chain which operates between grooved conical wheels. The sheave halves can be moved in and out so that the ratio is changed as the chain is forced to ride on a greater or smaller pitch diameter.

Gears: The variety of forms in which gearing is available is shown in Fig. 3. Gear pairs are arranged to show one of the more popular methods of classifying gear types by geometric orientation of connected shafts. Pairs shown in Fig. 3*b* and 3*c* have shafts which are normal to each other but any included angle can be accommodated with these types.

The tapered worm gear is a recent addition to the family of skewed-axis gears. The tapered pinion permits engagement with mating teeth generated on the face of a bevel gear. This arrangement provides a new and practical right-angle relationship, filling the gap that existed between shaft arrangements suitable for hypoid gears and worm drives. Gears can be produced on standard generating tools and have advantages of multiple tooth-contact and wide ratio range.

Current developments in gearing are pointed toward three objectives:

1. Greater capacity for a given size.
2. Greater speed capability.
3. Improved reliability.

Emphasis on light weight, not only in aircraft and missile equipment but also in other consumer products, accounts for the efforts to reduce the size of gears and at the same time increase their capacity. Experience in gear design gained in the development of automatic transmissions has resulted in significant improvements in machining, mounting, and specifying materials for mass-produced gears. Development of high-speed prime movers of the turbine type has necessitated increasing pitch-line velocities for the associated reduction gears.

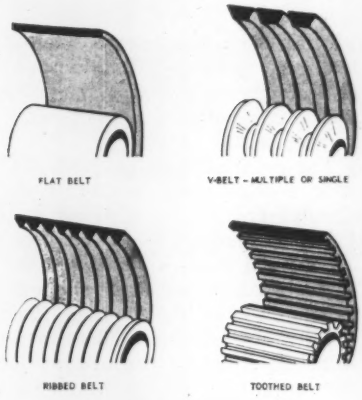


Fig. 1—Types of belt drives.

Design Procedure: Whether or not the transmission rate is of conventional design, three steps should be followed to achieve a final design:

1. Determine the requirements of the proposed transmission.
2. Make a preliminary selection of possible types.
3. Make a detailed selection of the optimum drive.

As a general rule, power to be transmitted, over-all speed ratio, the rotational speed of one of the shafts, and the life requirement of the drive are known. Other special restrictions or requirements may exist for a drive which are not immediately apparent but must be uncovered by study of the environment of the drive and specific function.

When the requirements of a transmission design have been reduced to firm specifications, the specifications should be compared with the properties and capabilities of the various types of transmissions available. Table 1 will facilitate a comparison between specific drive requirements and the properties and capabilities of the principal types of belt, chain, and gear transmissions. This tabulation consists of twelve factors which have been divided into general and special factors. General factors are those which are universally present in transmission de-

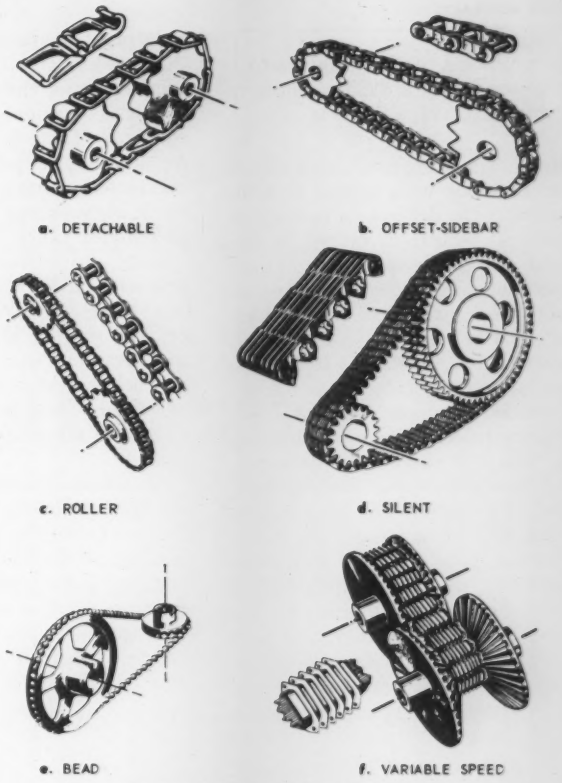


Fig. 2—Common chain types.

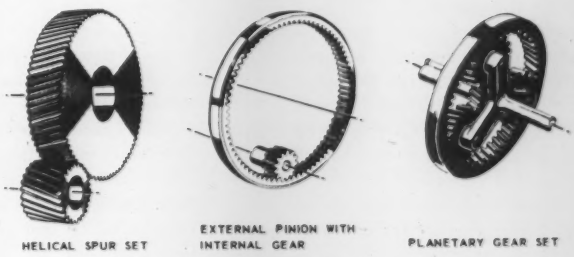


Fig. 3—Gears classified by shaft relationship.

sign problems, and special factors are those which are often encountered in particular situations.

Ratio: The primary decision which must be made with respect to ratio is whether the drive must be stepped in several reductions or can be designed as a single reduction. There is no inherent quality about any of the three transmission types which sets up a ratio limit beyond which they will not function. It follows, then, that this decision should not be made by application of some arbitrary rule of thumb which states the "limiting" ratio of one or another of the three drives. On the other hand, few drives are built which exceed the ratios quoted in Table 1. Thus, it is apparent that ratio limitations do exist. Analysis has shown that these limitations are space, cost, and efficiency.

A large single-reduction drive requires a large slow-speed element. Size of the high-speed element is set by the power transmitted. Area of the low-speed element in a single-reduction drive increases by the square of the ratio. On the other hand, the area of the two low-speed elements in two approximately equal reverted reductions is directly proportional to ratio.

Even if space for a drive is ample, the ratio of the drive may still be limited by the cost of the slow-speed element. As the size of these elements increases, cost rises rapidly whether they are gears, sprockets, or pulleys. At some ratio it will be found less expensive to pay for the extra parts necessary to step the drive than to undertake the cost of the one large part.

The most common method of providing an exceedingly large ratio in one reduction is the worm drive. Certain epicyclic arrangements can produce ratios as high as 2000 to 1. Although these drives are quite compact, they are seldom efficient, and this must be taken into consideration when such a device is to be employed.

Speed: In a transmission of a given power level, tangential speed and load are inversely related. These two quantities can be juggled by varying the element diameters until the optimum arrangement for the drive is realized. This optimum arrangement unquestionably will be that which gives the least costly drive utilizing the highest speed of which an economical drive type is capable. Table 1 shows the limiting speed of the principal types and, incidentally, testifies to the great range of tangential speeds which can be handled today.

Belts are capable of satisfactory operation at high speed. Flat belts have been operated at speeds of 24,000 fpm. The principal limiting factor is tension developed in the belt by centrifugal force. However, this force has less effect on belt capacity than previously assumed.

Generally, chains cannot be run as fast as belts and are limited in speed by the effect of impact loading. This loading occurs as the chain runs onto the sprocket forming a series of chords around the sprocket pitch line. Chordal action of chain is an inherent property since all chain is made of links. Ingenious mechanisms have been devised and some marketed which reduce the effects of chordal action to levels which make chain acceptable for a wide variety of applications.

Speed limitation of gear drives is a function of tooth profile accuracy, spacing accuracy, and the amount of tooth distortion under load. These errors cause impact as the teeth come into mesh and the effect increases rapidly with pitch-line speed. These effects have been minimized to permit gear speeds on the order of 30,000 fpm by the following means:

1. Development of more accurate machining methods including generating grinding processes to reduce geometric errors.
2. Modification of theoretical tooth profiles to compensate for load distortion.
3. Use of the finest pitch commensurate with strength to increase the number of teeth in contact.
4. Use of helical teeth to provide continuous line-of-action tooth contact.

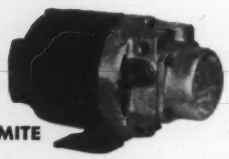
An important fact to remember is that speed affects reliability. In general, the slower the drive, the more reliable it is apt to be. Auxiliary components such as seals, bearings, and lubrication systems are similarly influenced by speed.

Load: If speed has already been selected, the nominal tangential load is directly proportional to the power requirement and will determine the cross sections of the load-carrying element.

The principal problem associated with consideration of load is the establishment of design load used in proportioning the drive parts. The design load, sometimes called equivalent load, is usually computed by multiplying the nominal load by a service factor. The service factor is supposed to account for the variations from constant load conditions caused by the type of service of the machine, the nature of the prime mover, and the peculiarities of the duty cycle. Nearly all manufacturers' catalogues tabulate service factors, and industry-wide standards and research bodies such as the American Gear Manufacturers' Association have compiled extensive data on the subject. The effect of load as a selection parameter is expressed in Table 1 as a number which represents the width of a drive relative to a spur-gear width of unity for a drive of the same geometry, power, and speed. Figures quoted are averages to indicate a relationship and are not offered as design data.

Perhaps the most troublesome and overlooked aspects of load definition are transient conditions. Although published service factors attempt to suggest the magnitude of shock effects and other phenomena, they should be leavened with practical experience—especially if the duty cycle is a complex one. For example, a high-inertia load in a duty cycle requiring frequent starts may demand starting torques so much more severe than the nominal steady-state torque that the transient starting condition will control the design. Belts which may be quite adequate for normal running conditions, may slip badly and be destroyed prematurely by transient conditions. Chains and gears are quite susceptible to impact damage and may, of course, generate undesirable noise under such conditions.

Life: In one of the few published works on belt fatigue life, it has been asserted that a calculable belt life exists although the materials involved are amorphous. This assertion is based on an impressive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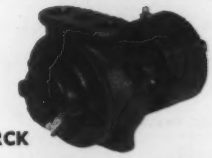
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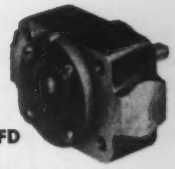
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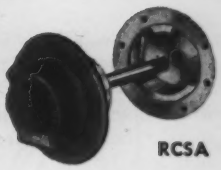
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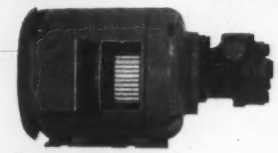

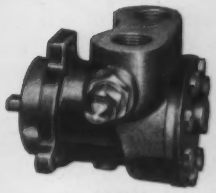
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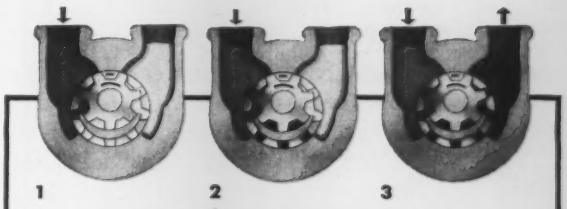

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In Tuthill internal gear pumps there are only two moving parts. The principle is based on the use of a rotor, idler gear and a crescent shape partition cast integral with the cover.

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body of data on V-belts which supports the application of the theory of cumulative fatigue. Design factors which determine the life of belts are speed, sheave diameters, load, and belt length.

These factors determine the magnitude of peak stresses suffered by each increment of belt length as it passes off the driven pulley and, again, onto the driver pulley, and the number of these peaks per minute. Knowledge of the magnitude and frequency of stress peaks permits calculation of expected life using experimental stress-life data for the various sizes of V-belts.

An important belt-life factor which should not be overlooked is the temperature at which a belt operates. This temperature is a function of internal friction in flexing, external friction in sheave contact, and ambient conditions. If the operating temperature of a belt can be limited to reasonable values by design, by control of ambient conditions, or by duty cycle, this can make the difference between virtually immediate belt failure and satisfactory life.

The useful life of a chain may be limited by either of two types of failure. The most important one is excessive elongation due to wear which results in the chain topping the sprocket teeth. The other is chain breakage because of fatigue-crack propagation in the link sides. The life of any chain drive should be assessed with respect to each of these to determine its suitability.

Most chain manufacturers' catalog selection procedures are based on fatigue-free operating life of 15,000 hr in which a 3 per cent wear elongation is suffered. Design factors which affect wear rate of chain have not been identified fully, let alone quantitatively evaluated. Hence, the procedure for designing for some other wear life is empirical and should be based on test results.

Considerable work has been done to analyze fatigue-failure characteristics of individual chain links. In general, this work has been undertaken to identify and eliminate stress raisers in the configuration of the chain links. Little information is available on the fatigue life performance of operating chain assemblies. This is not now especially

Properties and Capabilities of Belts, Chains, and Gears

TABLE 1

		BELTS					CHAINS			GEARS										
										Parallel Shaft			Intersecting Shaft			Skew Shaft			
		Leather (Flat)	Rubber Fabric (Flat)	Plastic (Flat)	Standard (Vee)	Steel Cable (Vee)	Toothed	Bead	Detachable	Pintle	Offset Sidebar	Inverted Tooth (Silent)	Roller	Straight Spur	Helical	High-Speed Herringbone	Straight Bevel	Spiral Bevel	Face Gear	Worm	Tapered Worm	Hybrid	Crossed Helical
GENERAL DESIGN FACTORS	Ratio	16:1	16:1	20:1	12:1	12:1	11:1	-	2-1/2:1	2-1/2:1	4:1	12:1	8:1	6:1	10:1	15:1	4:1	4:1	10:1	75:1	200:1	8:1	-
	Speed (Feet per min.)	6000	13,000	24,000	5000	8000	15,000	200	350	450	1000	6000	5000	4000	10,000	30,000	4000	8000	-	6000	6000	8000	6000
	Load (Equivalent width)	5.9	-	-	6.7	-	3.0	-	-	-	-	1.9	1.6	1.0	-	-	-	-	-	-	-	-	-	-
	Life	Depends on speed, pulley diameters, tension and total belt length. Published data and selection procedure available for vee belts. Generally less than 15,000 hours.						Catalogue selections based on 15,000 hours.						Substantial quantity of life information is available. Consult latest AGMA publications. Can be greater than 15,000 hours.									
	Center Distance	Independently variable — no interrelationship between pulley diameters and distance. Wear and retensioning takeup adjustment must be provided either by adjustable center distance or extra mechanism.						Independently variable — no interrelationship between sprocket diameters and center distance for a given ratio. Wear takeup required.						$CD = \frac{D+d}{2} + \frac{d(R-1)}{2}$ CD = center distance d = pinion pitch diameter D = gear pitch diameter R = Ratio			No center distance since shafts intersect.			Center distance is not directly related to ratio or pitch diameter.			
SPECIAL DESIGN FACTORS	Shaft Relationship	Connected shafts can be skewed up to 180° but belt capacity and life will be reduced accordingly.						Connected shafts can be skewed up to 90°	Connected shafts must be nominally parallel.					———			Any included angle can be ruled.	Normally 90° angles are used		90° skew angle		Any skew angle	
	Ratio Accuracy	Subject to slip and creep. Normal amounts are 1 to 5 % but amounts vary widely with tension ratio and contact pressure.					Delivers a fixed ratio	Delivers a fixed ratio. Instantaneous velocity rates vary cyclically with chordal action						All gearing delivers exact ratio. Instantaneous velocity is theoretically uniform — any variation is due to profile and spacing inaccuracies.									
	Vibration and Noise	Generally free of vibration. Subject to noise due to belt slap.			Quiet and free of vibration.		Vibration frequencies generated by tooth action	Noise and vibration are inherent due to chordal action. Large diameter sprockets, flywheels, and special silent chain designs can minimize but do not eliminate chordal action effects.						Frequency generation is inherent due to tooth contact. Practically noiseless drives can be achieved by special design and fabrication measures.									
	Efficiency	Up to 98% at rated steady load. Efficiency will reduce with varying load.						96 – 99%						96 – 99%			95 – 98%		-	20 – 98% Varies with size and ratio		95 – 98%	Wide variation depending on sliding.
	Lubrication	No lubrication required.						Capable of dry operation for short life applications or low load. Best life is obtained with splash or spray lubrication.						Lubrication required to achieve high efficiency. Plastic and impregnated materials are available for low-load dry applications.									
	Environment	Practically any environmental condition can be met by proper selection of material. Temperature range –60 to +225° F.						Can be operated in abrasive atmospheres with somewhat reduced life.		Cannot be operated open in abrasive atmospheres. Special materials are available for various types of corrosive atmospheres. Temperature range: –60 to 600° F				Cannot be operated open in abrasive atmospheres. Fully enclosed gear sets fairly independent of nature of atmosphere (providing seals are satisfactory). Ambient temperature range –60° to +300° F								
	Maintenance	Retensioning	Retensioning	Periodic application of special belt conditioner	Retensioning	Retensioning	-	Lubrication, retensioning and wear takeup.						Lubrication									

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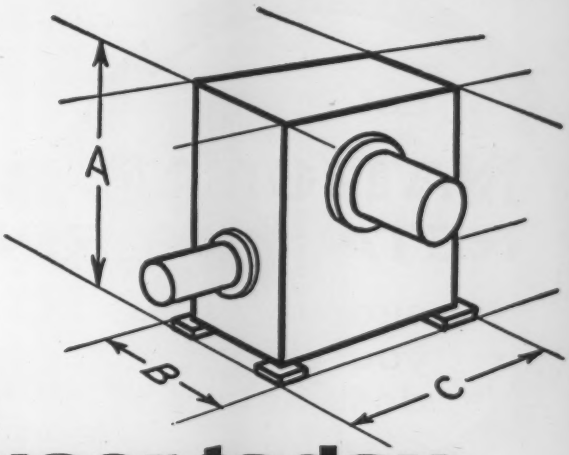

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Here again you have a choice. Cylindrical worm gearing is often used, and if it'll do the job, is worth consideration. But it's not the most compact possibility. The best way to shrink gears and still carry the load is the double-enveloping worm gear design. Both worm and gear are throated and the two literally wrap around each other. This brings center distance of the two shafts closer together and you can put them inside smaller housings.

Does this reduce load capacity? No sir! You can carry the same load with center distances up to 33% smaller than those of cylindrical worm gears. Or use the same center distance and carry a greater load. Will these gears hold up in operation? Sure, if you beef up the teeth, the bearings and the housing. Use straight-sided worm and gear teeth and you'll get all the strength there you'll ever need. Use large taper roller bearings with real B-10 life. Use a reinforced, heavy wall housing that won't distort under load. Put fins on it for added cooling and increased thermal horsepower capacity to meet your needs. Now, put the whole thing together and you've got a speed reducer that's a dilly.

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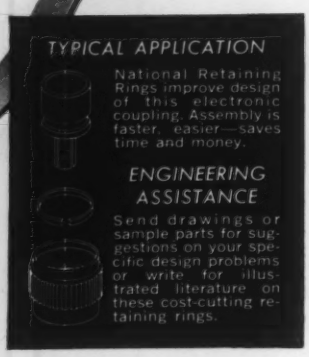
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Circle 499 on Page 19

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PATENTS 2,809,269; *2,837,360

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important since, with present design practices, most chains fail by wear elongation before they break in fatigue. It seems conceivable that application and evaluation of the theory of cumulative fatigue in chains would make possible a new rating structure which would permit use of much lighter chain for short-life applications.

The life of gears is expressed in terms of total stress cycles through which the teeth pass. Much experimental data on this subject have been compiled over a period of several years by various segments of industry. The automotive industry, for example, in its search for short-life, heavy-load gears has developed largely empirical procedures which permit reliable design of a low-speed range pinion for a life at full load of, say, 5 hr. At the other end of the spectrum, designers of gear sets for large turbine reducers, such as are used in ship propulsion, plan for a useful life measured in years of continuous service.

Owing to the impossibility of life testing such large and expensive units, much of the pressure for theoretical and experimental analysis of gear life has come from this section of the industry. The current proposed gear-rating formula of the AGMA is the most advanced expression of the results of those years of effort. It contains seven separate modifying factors, each of which accounts for a known operation or design variable affecting the rating of a pair of gears. One of the factors included is a measure of the expected life of the gear set in number of cycles.

Center Distance: Often the center distance of a drive is not specified, and the quantity becomes a variable which can be manipulated to the over-all benefit of the design. When the center distance is specified, either exactly or approximately, by the general arrangement of the machine, it will have a strong influence on the type of drive to be used.

A short center distance demands small pitch diameters and strongly suggests the use of gears, since these can have the greatest load-carrying capacity per inch of pitch diameter of the three drives. This is es-

pecially true if a large ratio is required. A spur pinion meshed with an internal gear, will permit effective use of short center distances. Epicyclic trains can, of course, be used to produce concentric drives. Large center distances generally compel consideration of belts or chain, since with these drives pitch diameter and center distance are not interrelated.

Since belts and chains both require periodic wear takeup and retensioning it is desirable to provide some adjustment when either of these drives is considered. If the centers are rigidly fixed, it may be necessary to use some type of spring or gravity-loaded tensioning device.

Shaft Relationship: The relationship referred to here is the geometric disposition of the shafts — parallel, intersecting, or skewed. If one of these relationships is imposed on the design, then restrictions on drive selection may exist. Most types of belting are fairly flexible. Flat belts can be used to connect shafts which are skewed at any angle and can operate with intersecting shafts if guide pulleys are used. V-belts can be operated successfully in quarter-turn arrangements. These measures all twist the belt and force a reduction in belt capacity because of unequal tension across the width.

Chain is quite limited in this respect. Only bead chain is presently available to connect nonparallel shafts. Bead chain can be used to drive shafts skewed to 90 deg of intersect at angles to 40 deg.

As indicated in the tabulation, gearing can be designed to connect shafts of any angular relationship. A limitation on load capacity does exist in the case of crossed helical gears which have point contact and must be worn in carefully if they are to have a significant load life.

Accuracy of shaft alignment is sometimes a factor in selection of a drive. Gearshaft alignment should be held to an accuracy on the order of 0.0005 in. per in. of gear face to provide satisfactory tooth contact. Shaft alignment for belt and chain drives need not be so accurate and can normally be achieved during assembly by the use of such devices as straightedges.

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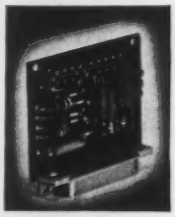

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Circle 502 on Page 19

Ratio Accuracy: This factor concerns the degree to which the drive transmits undistorted motion from the input to the output shaft. It is an important consideration in equipment such as precision measuring devices, recording instruments, and generating trains in machine tools.

Friction-belt drives are subject to speed distortion caused by slip and creep and thus have little application in devices requiring a high degree of ratio accuracy. Toothed belts, however, being positively engaged with their pulleys, are widely used in drives where exact ratio is a requirement. Chain drives produce a specific average ratio because of their positive engagement, but the instantaneous speed ratio varies constantly because of chordal action. If a chain is to be used in a drive requiring ratio accuracy, the amount of permissible distortion must be evaluated, and a chain and wheel size selected which will meet the requirements.

The system of involute geometry on which almost all gear-tooth design is based results in theoretically perfect action so that the instantaneous ratio is constant. As a result, the majority of trains requiring high-ratio accuracy employ gearing of one form or another.

Vibration and Noise: Control of noise presents a difficult technical problem both in definition and solution. Both vibration and noise are functions of the amount of repetitious impact loading present in the drive. Impacts may be inherent in the drive action or they may be caused by geometric errors. These impacts may be greatly amplified by the mounting of the drive or the drive housing.

Friction belts of constant cross section have no built-in frequency generation and usually run quietly, although some flat belts become noisy if the belt is allowed to slap the smooth pulley surface. Inherent vibration and some noise may result if cogged or toothed belts are used at high speed. Changes in belt configurations or in belt tension will usually solve the problem.

A chain drive will produce vibration and noise as a result of the chordal action of the links. The

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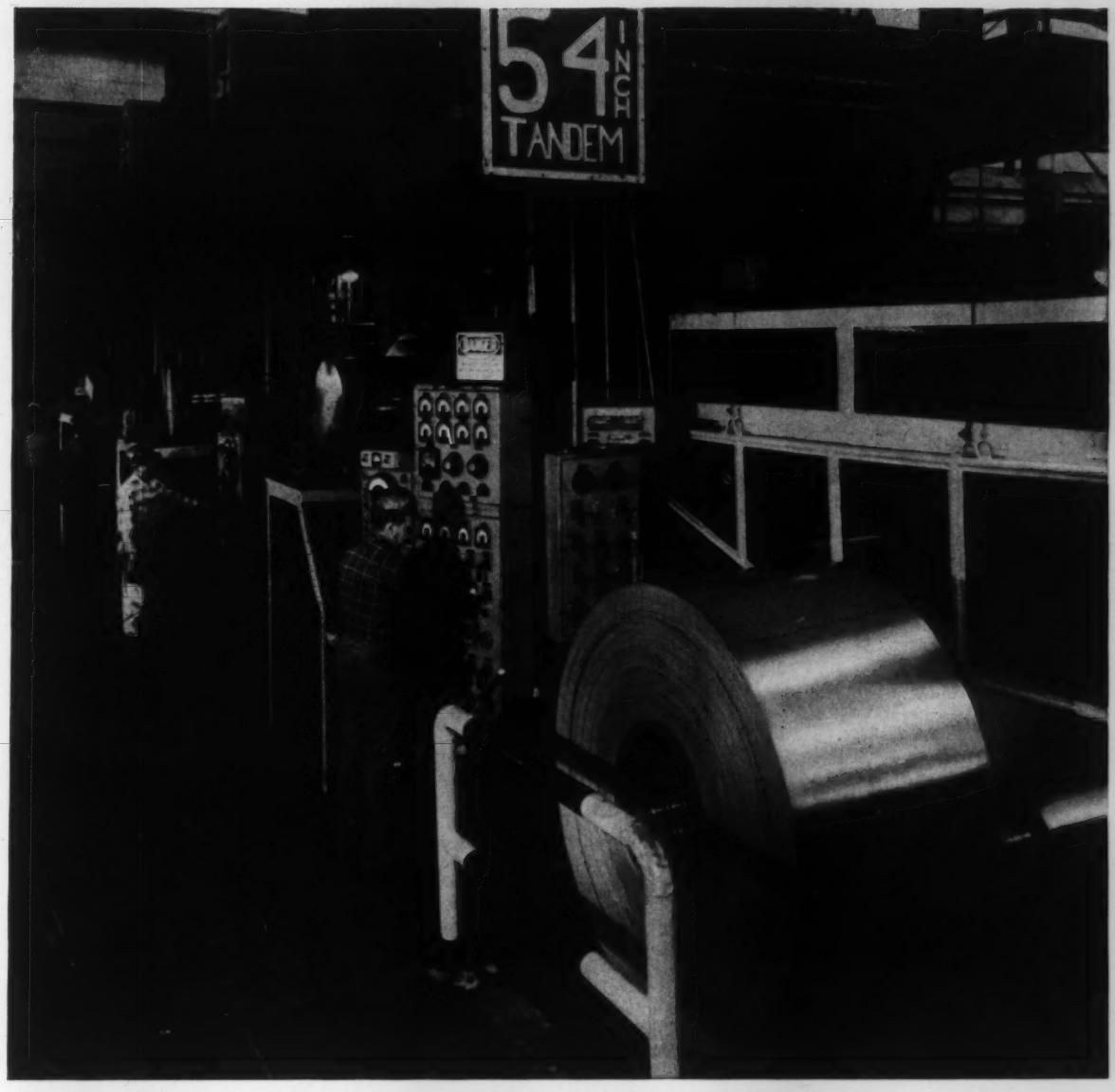

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effects can be minimized by selecting chain specially designed to run smoothly.

Gear drives produce noise and vibration in proportion to the amount of separation occurring as the tooth passes through mesh. This factor can be controlled by various means to produce quiet drives when required. Principal means of controlling noise are the use of fine-pitch helical teeth of modified profile cut to very close accuracy limits and employment of damping devices in gear structures, shafting, and housing.

Resonant vibrations must be avoided from an incremental load control as well as from a noise standpoint. Reliable prediction of resonance is difficult, and this matter must sometimes be dealt with after a design has been built.

Efficiency: This design factor determines the amount of input power which will be required to furnish a required output and the amount of cooling that must be provided. Belts, chains, and gears can all be designed to operate with efficiencies on the order of 95 per cent or better for one reduction, except for certain high-ratio arrangements mentioned previously. If the load cycle varies widely from the design load, then at low loads the efficiency of a belt drive will be somewhat less than that of the other types of drives. This is because a significant portion of the lost power is hysteresis loss in the belt.

Lubrication: Lubrication may not be permitted in many drives because of a need to eliminate contamination or periodic maintenance. Provision of oil-tight housings or greasing arrangements also may prove to be too expensive or space consuming. Where such limitations exist, they may control the selection of a drive. Table 1 presents current general practice.

Belts require no lubrication and are, therefore, particularly applicable for use where lubrication is not possible. Certain chains are now available which are self-lubricating. One manufacturer has produced a nylon chain coupling.

Considerable pressure exists from many segments of industry today to eliminate lubrication requirements

Circle 505 on Page 19

of gearing, and some progress is being made in development of impregnated materials and plastics. Nylon gearing of low-load capacity displays several attractive qualities.

Environment: Considerations pertinent to the various drive types are expressed in Table 1. Decisions regarding most of the listed conditions can be made quickly except in the case of extreme ambient temperatures.

Maintenance Requirements: Servicing functions include maintenance of a drive's geometry, cleanliness, and lubrication. Of all the drive types listed in the table, only toothed belting is claimed to be immune from requiring any of these functions.

Special service requirements are increasingly controlling the selection of transmissions. Machinery specifications for nuclear equipment have, in some cases, called for no maintenance whatever for the full design life of the transmission.

Detailed Selection: Final selection of a drive will result from a detailed study of the most promising transmission systems. Although this process consumes the majority of the engineering time devoted to the design of a transmission, the general procedure is simple and is basically the same regardless of the mechanism under consideration. In all cases, the known requirements of the drive must be supplemented by assumptions necessary to specify completely all of the general design parameters. The necessary cross section of the load-carrying element can then be calculated. If the resulting drive arrangement is not satisfactory, new assumptions must be made and the drive recalculated.

ASME paper, 59-MD-5, Design Engineering Conference, Philadelphia, May, 1959; 12 *pp.*

processes

Rolling Toothed Parts

H. Pelphrey, Michigan Tool Co.

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grooves, and threads. Modifications of the process can produce long splines, splined tubular parts, and smooth bearing diameters. Combinations of splines, threads, etc. are accomplished in sequence in one stroke.

ASME paper 59-PROD-12, *ASME Production Engineering Conference, Detroit, Mich., May,* 1959; 8 *pp.*

New Developments in Metalworking

E. L. H. Bastian, I. Rozalsky, and K. F. Schiermeier, Shell Oil Co.

Developments in methods for working new and unusual metals. Materials covered include nickel-cobalt base alloys and refractory metals. Problems associated with forming these materials are discussed, and recommendations are made for matching the material to the process. Metalworking methods covered are cold-press extrusion, rotary extrusion, radial draw forming, compression forming, creep forming, roll forming, hot forging, trepanning, explosive forming, spark-discharge machining, chemical milling, electrolytic machining, and ultrasonic machining.

ASLE paper 59AM 2A-3, *ASLE Fourteenth Annual Meeting, Buffalo, April,* 1959; 19 *pp.*

techniques

Product Reliability Measurement

D. F. Flanders, General Motors Corp.

An approach to reliability measurement by analysis of deficiency data feedback. Brief mention is made of the reporting documents and mechanics of the system. Examples of actual operational problems indicate the scope of the product-improvement program. Recommendations for organizing a reliability program are covered.

ASME paper 59-PROD-8, *ASME Production Engineering Conference, Detroit, Mich., May,* 1959; 8 *pp.*

Using the Moire Effect To Measure Plastic Strains

A. Vinckier and R. Dechaene, University of Ghent, Ghent, Belgium

A useful method for studying strain distribution in a metallic member during plastic deformation. Regularly spaced lines are drawn on a test specimen and on a glass plate.

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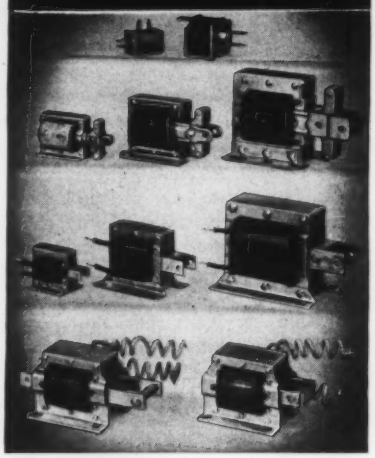

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ASME paper 59-Met-7, *ASME Metals Engineering Conference, Albany, May,* 1959; 9 *pp.*

Pressure Losses in Smooth Pipe Bends

H. Ito, Tohoku University, Japan

How to determine pressure losses for turbulent flow in smooth pipe bends of circular cross section. To make the data usable in practical design problems, results are discussed in relation to those found by earlier investigators, and empirical formulas for the bend-loss coefficient are given. Although discussion is limited to the case of smooth pipe bends, results should aid in clarifying present laws of bend resistance.

ASME paper 59-HYD-4, *ASME Hydraulic Conference, Ann Arbor, Mich., April,* 1959; 10 *pp.*

Numerical Control Application To Manufacturing Operations

P. Rusnov, The Warner & Swasey Co.

Applications of position-to-position numerical control, the preplanning required to realize its full potential, and some of its limitations. Techniques for designing for numerical control are included.

ASME paper 59-PROD-13, *ASME Production Engineering Conference, Detroit, Mich., May,* 1959; 8 *pp.*

TO OBTAIN COPIES of papers or articles abstracted here, write directly to the following organizations:

ASME—American Society of Mechanical Engineers, 29 West 39th St., New York 18, N. Y.; papers 40 cents to members, 80 cents to nonmembers.

ASLE—American Society of Lubrication Engineers, 5 North Wabash Ave., Chicago 2, Ill.; papers 35 cents to members, 50 cents to nonmembers.

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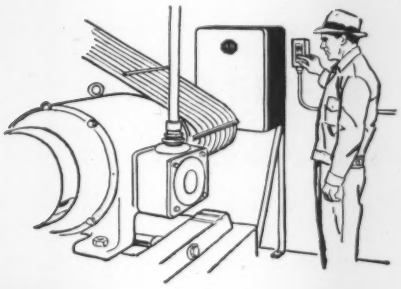

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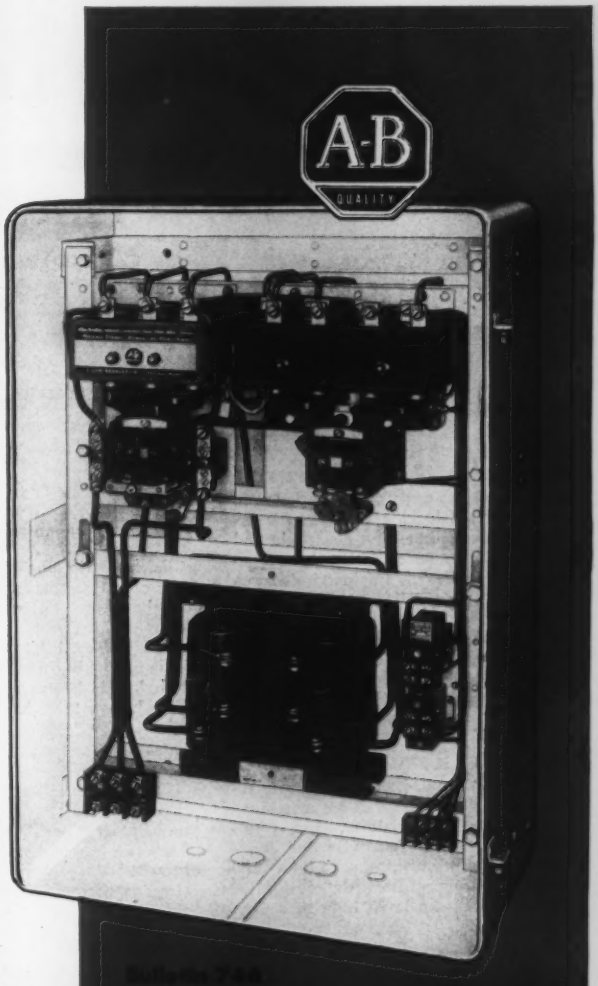

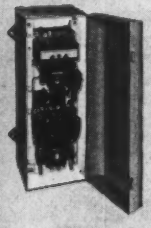

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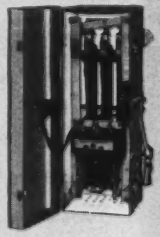

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Helpful Literature
for Design Engineers

For copies of any literature listed, circle Item Number on Yellow Card — page 19

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Versatile thrust and torque collar for transmitting thrust and torque loads to gears, pulleys, sheaves, cams, and bearings without shaft keys, splines, shoulders, or threads is subject of descriptive Catalog 59. 4 pages Kolock Products Co., Box 200, Lutherville, Md. C

Circle 601 on Page 19

Miniature Fasteners

Latest designs and configurations in miniaturized self-locking fasteners for assembly of small dimension electronic and avionic equipment are presented in illustrated Catalog 5711. Engineering drawings show various miniature hex, clinch, and floating anchor nuts. Text discusses economy and weight savings provided by different materials and design shapes. 32 pages. Elastic Stop Nut Corp. of America, 2330 Vauxhall Rd., Union, N. J. D

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Circle 604 on Page 19

Breadboard Parts

All parts necessary for the easy assembly of complicated gear trains and mechanisms are described in illustrated Catalog 575. Schematics and basic synchro transmitter and receiver, mechanical resolver, and other systems are covered. 24 pages. Beckman Instruments, Inc., Helipot Div., 2500 Fullerton Rd., Fullerton, Calif. L

Circle 605 on Page 19

Blind Rivet

Conical Keystone Lock blind rivet for high strength structural fastening is subject of revised Brochure 8-388. Features are outlined and typical applications are shown. Dimensions of standard and oversize types are given. 16 pages. Huck Mfg. Co., 2480 Bellevue Ave., Detroit 7, Mich. H

Circle 606 on Page 19

Molded Plastics

Facilities for producing custom molded plastic parts are briefly described in Folder 310. Typical decorative panel pieces and emblems are shown. Press facilities range from 4 to 48-oz capacity. 4 pages. Yardley Molded Plastics, Inc., 142 Parsons Ave., Columbus 15, Ohio. G

Circle 607 on Page 19

Cylinders

Brief descriptions of Squair head, standard and Spacemaker air and hydraulic cylinders, and Spacemaker high pressure hydraulic cylinders are found in illustrated Folder FPD 6-59. References to bulletins with complete specifications are included. 4 pages. Tomkins-Johnson Co., Jackson, Mich. H

Circle 608 on Page 19

Variable Speed Drives

Detailed specifications, prices, application information, and engineering data on Reeves Vari-Speed Motodrives are found in comprehensive illustrated Catalog M-592. Extensive range of types, sizes, speeds, and ratings is offered. Section is devoted to modifications ad accessories. 88 pages. Reeves Pulley Co., Columbus, Ind. J

Circle 609 on Page 19

Carbon Welding Products

Use of welding carbon products, including rods, plate, and paste, as used to make difficult welding repair work easy is described in pocket-size manual. Illustrations show basic applications. The use of carbon plate, rod, and paste eliminates the need for many jigs and fixtures. 12 pages. Arcair Co., Box 431, Lancaster, Ohio. G

Circle 610 on Page 19

Industrial Gases

Production and commercial applications of all currently available industrial gases is subject of comprehensive Catalog ADC 892. Included are oxygen, nitrogen, argon, helium, acetylene, hydrogen, carbon dioxide, and the rare gases. Various systems of delivery and storage are detailed. Table of physical properties is included. 32 pages. Air Reduction Sales Co., 150 E. 42nd St., New York 17, N. Y. D

Circle 611 on Page 19

Ceramic Filter Element

Uniform structure and particle retention, heat and corrosion resistance, and a wide porosity range are features of the C.F.C. porus ceramic filter element. Subject of illustrated Bulletin GEO-515, it is suited for liquids and gases. 4 pages. Commercial Filters Corp., 2 Main St., Melrose 76, Mass. B

Circle 612 on Page 19

Copper & Brass Tube

Base price is kept separate from the size extra in the copper and brass tube price list and pricing guide. A table shows standard commercial tolerances. 4 pages. Small Tube Products, Inc., Spring Meadows, Altoona, Pa. C

Circle 613 on Page 19

Speed Changers

Speed ratios are continuously adjustable over a 25:1 range with the Series 2 miniature speed changers, subject of Bulletin 96. Torques from 5 to 40 oz-in. are handled, and speeds range up to 10,000 rpm. 2 pages. Metron Instrument Co., 432 Lincoln St., Denver 3, Colo. K

Circle 614 on Page 19

Filter Assemblies

Dimensions of 66 filters with capacities up to 43 gpm for service up to 5000 psi at −65 to 275° F are found in Bulletin A-1081. They have stainless steel Rigimesh elements rated for 98 per cent removal of 2, 5, and 10-micron particles. 4 pages. Aircraft Porous Media, Inc., 30 Sea Cliff Ave., Glen Cove, N. Y. D

Circle 615 on Page 19

Making Machine Brackets

Design and production of machine brackets using welding fabricating techniques is subject of Design Ideas No. 22 folder. Sketches of various types are shown. 4 pages. Lincoln Electric Co., Cleveland 17, Ohio. F

Circle 616 on Page 19

Nonferrous Alloys

Designed to assist in the selection of copper, brass, and bronze alloys for particular products and services, illustrated folder contains data on composition and properties of numerous alloys. Specification table is included. 8 pages. Bridgeport Brass Co., 30 Grand St., Bridgeport, Conn. B

Circle 617 on Page 19

Welded Steel Pulleys

"Die Crown Welded Steel Pulleys" is title of Book 2540 which gives selection and engineering data on the hydro-expansion-formed belt conveyor pulleys. They are concentric to within 0.030 in. 8 pages. Link-Belt Co., Prudential Plaza, Chicago 1, Ill. J

Circle 618 on Page 19

To Venus and back in 5 minutes with the help of Penmetal Squarex

Here is the 84-foot diameter space antenna used to establish contact with the planet Venus — some 28 million miles distant. Built by D. S. Kennedy & Co., it is installed at MIT's Lincoln Laboratory at Westford, Massachusetts. Microwaves beamed from the upturned reflector made the round trip in about five minutes.

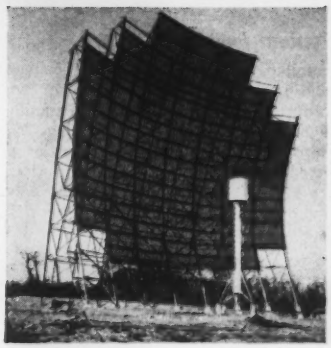
Within the periphery of the dish is *Penmetal Squarex**, an expanded aluminum mesh having square openings instead of the usual oblong diamonds. The most versatile reflecting surface yet developed for radio, radar and telemetry reception, it provides constant response for radio energy regardless of polarization. In addition, this mesh is extremely strong, yet light in weight. The pattern was evolved through the joint efforts of D. S. Kennedy & Co. and Penn Metal Company.

Squarex is available in a range of mesh sizes from ¼" to 2⅜", to cover frequencies from less than 100 megacycles to more than 10,000 megacycles. It is made in either aluminum or steel.

Squarex is only one example of many unique products developed by Penn Metal Company in cooperation with industrial designers during the last 90 years. This experience is available to you for the development of special meshes to meet your individual requirements. Write for further details.

PENN METAL COMPANY, INC.

General Sales Office: 40 Central Street, Boston 9, Mass.
Plant: Parkersburg, W. Va.
District Sales Offices: Boston, New York, Philadelphia, Pittsburgh, Chicago, Detroit, Dallas, Little Rock, Seattle, San Francisco, Los Angeles, Parkersburg, St. Louis



This 120-foot antenna was designed and built by D. S. Kennedy & Co., of Cohasset, Mass., for long-distance radio communication. Here, too, the reflecting surface is *Penmetal Squarex*.

PENN METAL COMPANY INC. 90th YEAR 1869 – 1959

PM-219

*Trade mark registered; patent applied for.

Circle 513 on Page 19

Shut-Off Valves

No. 10 safety shut-off valve shuts off automatically if a break in the pipe line occurs, thus preventing loss off product and hazardous conditions. In case of fire a fusible link melts to close the valve. Application and technical data on this valve are found in Bulletin F-47. 4 pages. OPW-Jordan, 6013 Wiehe Rd., Cincinnati 13, Ohio. G

Circle 619 on Page 19

Electromagnetic Controls

Catalog accessory kit for electromagnetic control Catalog 57-S contains recently issued catalog sheets and a catalog file pocket for the original catalog. Sheets cover ac relays, solenoids, automatic engine starting controls, automatic battery chargers, break glass switches, close differentiai relays, and remote control switches. Automatic Switch Co., Hanover Rd., Florham Park, N. J. D

Circle 620 on Page 19

Thin Electric Motors

Thinline dripproof and totally enclosed motors, rated from 1 to 5 hp, are subject of illustrated Bulletin GEA-6927. Motors are designed for limited space applications in machine tools, blowers, and other equipment. Interchangeable flange dimensions chart is included. 8 pages. General Electric Co., Schenectady 5, N. Y. C

Circle 621 on Page 19

Worm Gear Sets

Basic information on Delroyd worm gearing and selection data are contained in illustrated Catalog 3800. Information on standard design worm gears, single and double extended worm and mounting, and single and double extended worm shaft are included, along with specifications of available gear units. 24 pages. De Laval Steam Turbine Co., Trenton 2, N. J. C

Circle 622 on Page 19

Custom Castings

Manganese, alloy, and carbon steel can be used in the manufacture of cast special products to customer specifications. Photographs in Bulletin 1065 show the company's wide range of manufacturing skills in producing castings up to 18,000 lb. 4 pages. Columbia Steel Casting Co., 933 N. W. Johnson, Portland 9, Oreg. M

Circle 623 on Page 19

Chemical Feed Pump

Hydraulically balanced Teflon slack diaphragm not directly connected to the plunger is a feature of the chemical solution feed pump described in Bulletin 71R1000. It injects one or two solutions at up to 65 gal per 24 hr. 2 pages. Fischer & Porter Co., 141 Jacksonville Rd., Hatboro, Pa. E

Circle 624 on Page 19

Stepping Motors

Precise bidirectional controlled step output for input signals up to 3 kc is obtained with instrument size digital stepping motors and solid state control described in a technical paper reprint. Details of the Digitork units are included. 12 pages. Teller Co., Box 989, Butler, Pa. F

Circle 625 on Page 19

Plate Magnets

Data which aid in selection of Indox V plate magnets for existing chutes, ducts, conveyors, and other materials handling equipment are contained in Bulletin 1074. Recommended sizes for conveyor size, speed of flow, size of material, etc., are given. 8 pages. Stearns Magnetic Products, 635 S. 28th St., Milwaukee 46, Wis. K

Circle 626 on Page 19

Filter Elements

Micropleat replacement filter element for aircraft main fuel line filters is described in Data Sheet 102. Flow-rate pressure drop curves, cross-sectional drawings, and an installation drawing are included. 2 pages. Bendix Aviation Corp., Bendix Filter Div., 434 W. 12 Mile Rd., Madison Heights, Mich. H

Circle 627 on Page 19

Flowmeters

Type 20 turbine flowmeters for measuring the flow of jet fuel, gasoline, oil, water, and acid and alkali chemicals, is subject of Bulletin 1384. Specifications and flow ranges are included. 4 pages. George L. Nankervis Co., Cox Instruments Div., 15300 Fullerton Ave., Detroit 27, Mich. H

Circle 628 on Page 19

Computer Techniques

First issue of Donner Tech Notes, a publication dealing with analog computer techniques and applications, covers this subject: "How To Simulate a Nonlinear Control System with an Analog Computer." Diagrams of typical control systems and plots show response at various points with different parameters. 4 pages. Donner Scientific Co., 888 Galindo Rd., Concord, Calif. M

Circle 629 on Page 19

Valves & Accessories

Filters, check valves, unloading valves, relief valves, and fuses of hydraulic power systems are described in illustrated Catalog 3000. Detailed specifications and selection data are included, along with dimensional diagrams. 12 pages. Waterman Engineering Co., 725 Custer Ave., Evanston, Ill. J

Circle 630 on Page 19

Titanium Fasteners

Standard titanium aircraft fasteners made by this company are shown with appropriate military and NAS standard designations in illustrated Catalog 2559. Comparative titanium-steel properties are covered. Facilities for producing titanium specials are reviewed. 12 pages. Standard Pressed Steel Co., Box 102, Jenkintown, Pa. C

Circle 631 on Page 19

Diesel Engine

Developing 385 hp at 2100 rpm, the UDT-817 direct start diesel engine is described in Folder CR-684-1. Fuel consumption graphs, performance curves, cutaway views, and power unit combinations are included. 4 pages. International Harvester Co., 180 N. Michigan Ave., Chicago 1, Ill. J

Circle 632 on Page 19

Stainless Steel Tubing

Small tubing drawn from PH 15-7 Mo, a precipitation hardening stainless steel possessing outstanding mechanical properties at elevated temperatures, is subject of Memo 120. Mechanical properties, characteristics, and applications are covered. 4 pages. Superior Tube Co., 1578 Germantown Ave., Norristown, Pa. E

Circle 633 on Page 19

Missile Electric Connectors

Principal types of connectors used in missiles and their ground-control equipment are subject of illustrated brochure. Hand, semiautomatic, and automatic tooling for installing connectors in missile electrical systems are discussed, and how connectors are engineered for requirements of systems is explained. 12 pages. Burndy Corp., Norwalk, Conn. B

Circle 634 on Page 19

Adjustable Speed Drives

Characteristics of the new K-2 electronic control system which adapts it to two recently introduced adjustable speed drives with outputs from 1 to 5 hp, as well as to Adjusto-Speed drives rated up to 30 hp are pointed out in Bulletin K-2. Control maintains set speed within 2 per cent. 8 pages. Eaton Mfg. Co., Dynamatic Div., Kenosha, Wis. F

Circle 635 on Page 19

Time Delay Relay

Descriptive folders on the new Agastat SM-2 miniature time delay relay explains application and operation of this 4⅝ x 1 13/16 x 1½-in. control for missile, aircraft, electronic, and industrial uses. Timing ranges are from 0.03 to 120 sec for ac and dc service. 4 pages. Elastic Stop Nut Corp. of America, AGA Div., Elizabeth, N. J. D

Circle 636 on Page 19

Glass-Ceramic

Pyroceram is a family of crystalline ceramics that is converted from the original glassy state by nucleating agents and heat treatment. Electrical, mechanical, thermal, and chemical properties of two types are given in Progress Report PY-3. Design considerations and applications are covered. 8 pages. Request on company letterhead from Corning Glass Works, Corning, N. Y. N

Centrifugal Castings

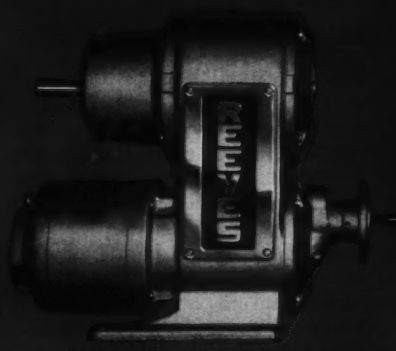
High resistance to abrasion, ability to retain hardness at elevated temperatures, and immunity to most corrosives are provided by centrifugal castings of a cobalt-chromium-tungsten analysis. Data on the casting process, analysis, physical properties, machining, and applications are covered in illustrated brochure. 20 pages. Request on company letterhead from Stoody Co., 11928 Slauson Ave., Whittier, Calif. L

REEVES®

Vari-Speed Motodrives mean versatility in variable speed

101 *different standard assemblies*

18 *different standard right angle assemblies (fractional only)*



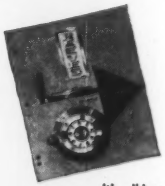
9 *different standard inverted vertical assemblies*

32 *different standard flange assemblies*

REEVES has the variable speed answer for virtually *any* installation . . . with *standard* Motodrive units. This rugged, compact power package is available from ¼ to 20 hp., 1.7 to 4660 rpm., in 2:1 thru 10:1 speed variations. Single, double and triple stage reducers provide gear ratios from 1.17 to 195:1. Other Motodrive units up to 40 hp.

There's space-saving versatility, too . . . REEVES Motodrives come in two styles: "C" flow, as illustrated, and "Z" flow, where motor is on opposite side of the case from the output shaft.

Extra precision . . . a complete line of controls, ie. AIRtrol (a pneumatic positioner), electric remote control, mechanical controls, magnetic brakes and tachometers. **Extra versatility** . . . to meet specific needs, REEVES offers a full array of modifications, ie. special motors, shaft extensions and scoop mountings for foot-mounted motors.



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REEVES PULLEY COMPANY
Division of **RELIANCE** ELECTRIC AND ENGINEERING CO.
COLUMBUS, INDIANA
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R MASTER
REEVES

New Parts and Materials

Use Yellow Card, page 19, to obtain more information

Lightweight Counter

provides direct reading in mils

Small, lightweight counter is available for applications requiring precise angular measurement coupled with direct reading in mils. Instrument is about 2¼ in. long and weighs less than 4 oz. One revolution of driveshaft, mounted in a porous-bronze bushing, registers 10

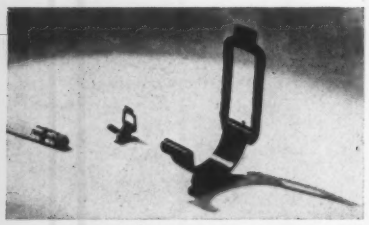
mils in ¼-mil increments on face of instrument. Thus 640 revolutions indicate 6400 mils or 360 deg. Minimum life of counter is 1 million driveshaft rotations at 1200 rpm. Unit passes humidity and standard 50-hr salt-spray tests, and meets military requirements for shock, vibration, corrosion resistance, and performance under other adverse environmental conditions. Counter operates over temperature range of −55 to +85 C. At minimum temperature it requires maximum torque on driveshaft of 1 oz-in.; at room temperature, only 0.5 oz-in. is needed. **Veeder-Root Inc.**, Hartford 2, Conn. B

Circle 637 on Page 19

Cradle Clip

miniature unit takes 5/32 to ¼-in. wire bundles

Insuloid Cradleclip system for securing or separating wire groups found in electrical harnesses or other wire



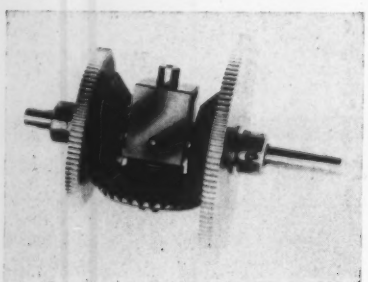
and cable installations is now available in a miniature size (left). Unit also fastens pressure tubing for missiles, aircraft or control assemblies, and electrical components such as capacitors, resistors, transistors. Clip consists of tough, U-shaped nylon cradle into which a bundle of wires or a component fits, and an extensible neoprene clip permanently hinged to top of one side of cradle. Clip cinches across U-opening and locks under an inverted lip on other side of cradle. Miniature Cradleclip unit accommodates diameters of 5/32 to ¼ in. **Electrovert Inc.**, 124 E. 40th St., New York, N. Y. D

Circle 638 on Page 19

Solid-Shaft Differential

is miniature, three-gear type

Miniature, precision three-gear differential is for application in electronic computers and fire-control systems. It has backlash of 8 min of arc, break-away torque of 0.3 oz-in., and tumbling circle of 1.380 in. Maximum recommended load



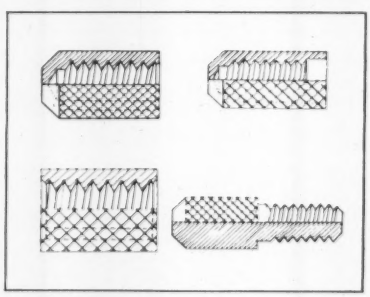
at 2500 rpm is 75 oz-in. Featuring six precision bearings, solid-shaft differential is constructed entirely of 303 stainless steel except for spider gear, which is 2024S-T aluminum. Over-all length of differential proper is 1.888 in., and shaft diameter is 0.1847 in. Shaft lengths are available up to 4 in. End spur gears are available to suit specific purposes and are permanently attached at factory. Lesser backlash and/or demountable end gears are also furnished. **Dynamic Gear Co.**, 20 Merrick Rd., Amityville, L. I., N. Y. D

Circle 639 on Page 19

Brass Inserts

for molding in plastics, ceramics, and rubber

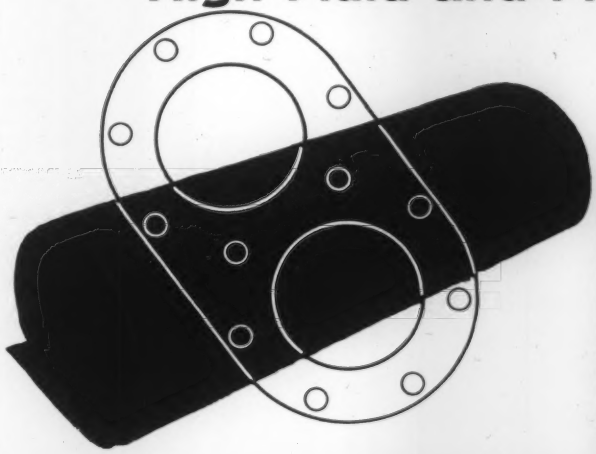
Standard brass inserts are now available in addition to plain, brass-plated, and clear-anodized aluminum



inserts for molding in plastics, ceramics, and rubber. Type A (top, left) with closed end, Type B (bottom, left) through threaded, and Type C (top, right) with closed end and countersunk hole, are tapped to ASME Specifications with Class II threads in sizes from 4-40 to ¼-28. Holes are reamed after tapping to insure ease of placing inserts on locating pins and in assembly. Outside walls are coarsely knurled to assure holding power against high torque. Type D (bot-

VICTOPAC

Asbestos-Synthetic Rubber Gasketing Durable under Heat, High Fluid and Flange Pressures



Seals against oil, engine fuels (liquid or vapor) and coolants, steam, hot or cold water

Supplied in Sheets . . . or Finished Gaskets
Made in standard thickness:
1/64″—1/32″—1/16″—3/32″—1/8″

This tough, completely homogeneous sheet packing is composed of long-fiber asbestos and synthetic rubber, bonded under heat and pressure.

While thoroughly dense in structure, Victopac has sufficient compressibility for effective sealing under light or heavy flange loading. Its resistance to heat permits usage where plant fiber packings deteriorate.

CONDENSED SPECIFICATIONS

Type	SAE-ASTM Spec.	% Compression 5000 Psi. Load	Recovery %	Minimum Original Tensile	Max. Thickness Change in ASTM Oil No. 1— 5 hrs. at 300 deg. F.
1	G-1111-1 *P1161A	12±5	40	1800 psi.	20%
1B	G-1111-1 (Federal Spec. HH-P-46A *P1161A	12±5	40	1800 psi.	20%
2 Graphite coated, one side	G-1111-1 *P1161A	12±5	40	1800 psi.	20%
3 Graphite coated, two sides	G-1111-1 *P1161A	12±5	40	1800 psi.	20%
50V	G-1122-1 (AMS 3232F) (Navy Spec. 33-P-13c) *P1141A	12±5	40	2000 psi.	10%
60V	G-1123-1 (AMS 3230 and 3231) *P1151A	12±5	40	2000 psi.	15%
70V	G-1122-1 (AMS 3232F) *P1141A	12±5	40	2000 psi.	10%

*Latest ASTM No. D1170-58T, SAE No. 90R and MIL-G-12803A specifications.

Made in 7 types — Typical uses

Victopac is widely specified for automotive and industrial machinery applications. Choice of seven basic types provides economical sealing for each use. All types conform to SAE-ASTM specifications and are certified to federal, military or customer specifications where needed.

Typical applications include speed reducers, transmissions, differentials, gear case covers, pipe flanges, refrigeration, pumps, oil coolers, internal combustion engines, etc. Victopac's uses are almost unlimited.

Test samples supplied free

Your inquiry, stating proposed application, will bring you sample sheets of recommended type with full technical data. Request through your Victor Sales Engineer or directly to factory.

Victopac is available in sheet sizes 58″ x 62½″ and 58″ x 125″. Write for special price list.

Victor Mfg. & Gasket Co., P.O. Box 1333, Chicago 90, Ill. Canadian Plant: St. Thomas, Ont.

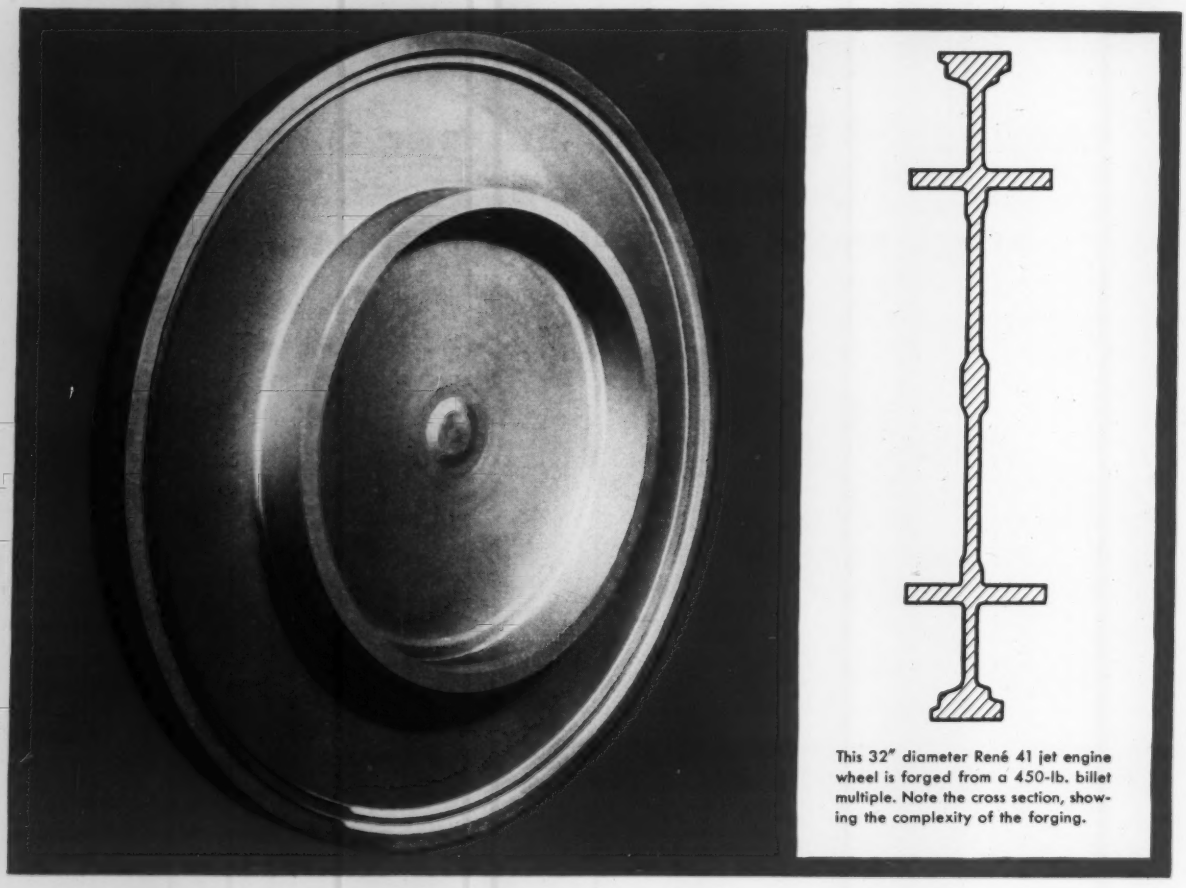
VICTOR

Sealing Products *Exclusively*

1909 — 1959 50th ANNIVERSARY GASKETS-OIL SEALS

GASKETS • PACKINGS • OIL SEALS • MECHANICAL SEALS

Metallurgical Memo from General Electric



This 32" diameter René 41 jet engine wheel is forged from a 450-lb. billet multiple. Note the cross section, showing the complexity of the forging.

RELIABILITY: the plus in critical parts made from General Electric vacuum-melted alloys

Metallurgical Products Department reports on René 41®, a G-E super-strong alloy whose ease of fabrication points to new uses where you need dependability

General Electric's René 41 high-temperature alloy is one of the strongest materials that can be successfully formed, forged, or welded. Made by the General Electric *vacuum-induction-melting* process, René 41 is essentially free from inclusions, gases, and oxides.

This cleanness increases fatigue and stress rupture strengths . . . makes possible operational reliability in finished parts. For example, René 41 jet engine wheels, like the one shown above, have a tensile strength of over 100,000 psi at 1650°F. They are *forged* from 450-lb. multiples of René 41, vacuum-induction-melted by General Electric. René 41 is so ductile that it can also be drawn into wire as fine as 0.001". *No alloy with comparable mechanical properties can approach this workability.*

René 41 is just one of the high-purity General Electric vacuum-melted alloys that can be ordered in sheets, bars, billets, wire, or castings. Will one help solve a design problem for you? For more information—or for the assistance of a G-E engineer—write: *Metallurgical Products Department of General Electric Company, 11159 E. 8 Mile Street, Detroit 32, Michigan.*

René 41 is a trademark of the General Electric Company

METALLURGICAL PRODUCTS DEPARTMENT

GENERAL ELECTRIC

CARBOLOY® CEMENTED CARBIDES • MAN-MADE DIAMONDS • MAGNETIC MATERIALS • THERMISTORS • THYRITE® • VACUUM-MELTED ALLOYS

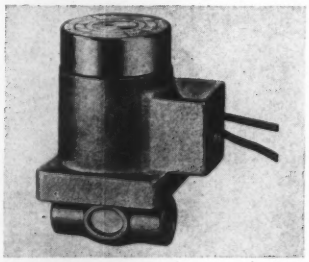
tom, right) has a threaded stud and is properly proportioned to assure maximum strength. It is threaded to the same specifications and sizes as other inserts. Type D can be used with Type C, combining as male and female components. **Yardley Precision Products Co.**, 30 Afton Ave., Yardley, Pa. E

Circle 640 on Page 19

Miniature Solenoid Valves

are small-ported, explosionproof units

Two and three-way direct-acting solenoid valves have brass or stainless-steel bodies and coil housings of high-strength cast iron, cadmium plated, with ½-in. threaded conduit hub as integral part of housing. Small-ported, explosionproof designs are available for normally closed, normally open, or universal operation. Valves have ac shading coils of fine silver, fully rotatable coil housings for electrical connections from any angle, ability to operate equally well in any mounted position, and broad selection of pipe and tube connections over an orifice range of 1/32 to ⅛ in. in Series 90, two-way types, and 1/32 to 1/16 in. in Series 95, three-way types. **Hoke Inc.**, 91 Piermont Rd., Cresskill, N. J. D



Circle 641 on Page 19

Acceleration Switch

offers control over 5 to 50-g range

Series 5 acceleration switch is designed for applications involving critical control or limits on acceleration changes in two directions. Used in missiles and aircraft, it is responsive to axial acceleration in one or both directions from 5 to 50 g. Actuating time is 20 millisec, with accuracy within 5 per cent. Unit has only one moving part, a precision-ground ball held by a uniform magnetic field. Ball is released to close or open an electric circuit when force of acceleration exceeds magnetic force. Switch is factory preset, with nominal setting specified by user. Service life is 100,000 cycles. Switch meets MIL-E-5272A. **Inertia Switch Inc.**, 311 W. 43rd St., New York 36, N. Y. D

Circle 642 on Page 19

General-Purpose Adhesive

provides noncrystallizing, flexible bond

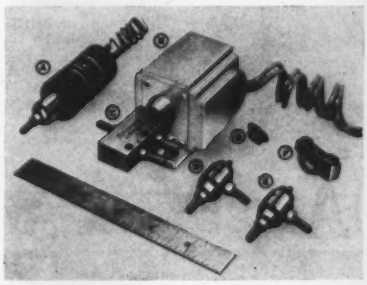
Rez-N-Glue adhesive provides a high degree of adhesion between many surfaces through a noncrystallizing, permanent, flexible bond. It is a clear vinyl base product with very high solids content that makes it well suited for cementing dissimilar plastics and plastics to nonplastics. It can be used as a wet bonding agent, contact cement, or by reactivation technique. **Schwartz Chemical Co. Inc.**, 50-01 Second St., Long Island City 1, N. Y. D

Circle 643 on Page 19

Miniature Solenoids

activate air valves

Two miniature air-valve-actuating solenoids, one for dc and one for 115-v ac operation, are now available. Dc type operates miniature two and three-way air valves. Recommended maximum operating pressure is 150 psi air. Model AVS-



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Want continuous production...to cut installation costs? Investigate the advantages of Rex Segmental Rim Sprockets and Traction Wheels. Tough, long-lasting special cast steel rims bolt simply to either split or solid hub body. When, after long service life, replacement is required, all you do is replace the worn rim...the hub body remains on the shaft. Mail the coupon.

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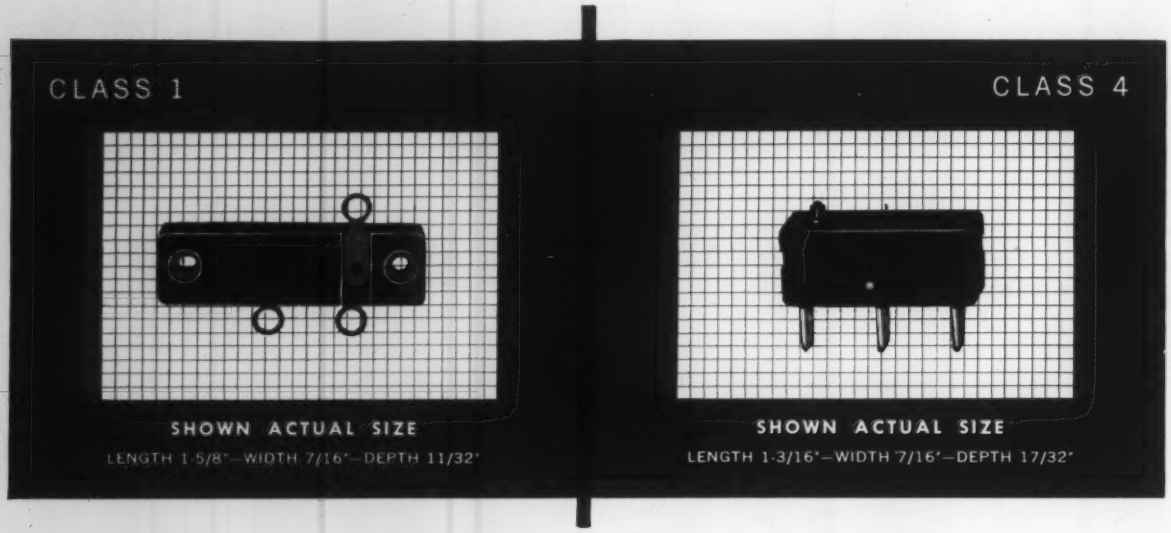
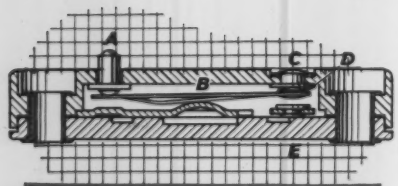
City.....*Zone*.....*State*.....

Circle 517 on Page 19



Shaves Space:

DETROIT TyniSwitch® does KING-SIZE job



HOW IT WORKS

Pressure applied to pin plunger "A" is transferred to spring blade "B". When the actuating force (pressure) on "A" exceeds the resistance of spring blade "B", the free end of blade "B" "snaps" downward at high velocity, breaking contacts "C" and "D" and making contacts "D" and "E".

When pressure on pin plunger "A" is released, blade "B" returns with a snap (again at high velocity) to its normal position, breaking contacts "D" and "E" and making contacts "C" and "D".

Space at a premium in your product? Then specify Detroit TyniSwitches. They are smaller than other snap switches of equal rating, yet give the positive action, long life and precision you need. They are virtually bounceless and resist shock and vibration.

Class 1 TyniSwitches are top mounted and top actuated. Class 4 is side mounted and top actuated. Both have a wide variety of actuators and terminals.

Write for bulletins 263 and 270. Detroit Controls Division of American-Standard, 5900 Trumbull Avenue, Detroit 8, Mich.

Underwriters' Laboratories listed and
Canadian Standards Assoc. approved.
15 Amp. 125/250 V. A.C. Non-Ind. 1/2 H.P. 125/250 V. A.C.
Contractual approvals for U.S. Gov't applications

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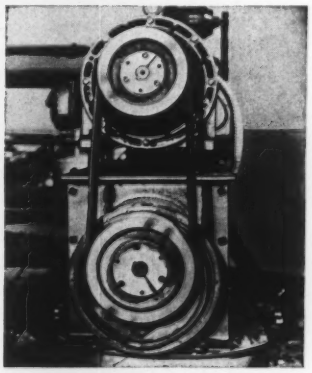
AMERICAN-Standard
DETROIT CONTROLS DIVISION

12 is for 12-v dc operation at 0.64 amp, and Model AVS-24 for 24-v dc at 0.32 amp. Units measure only 1⅜ in. diam by 2 5/16 in. long. Model AVS-115, for 110-125 v ac line operation at 0.81 amp, operates two, three, and four-way valves. It is housed in a polished, cast-aluminum case measuring 2 x 2 1/16 x 3 3/16 in. over-all, including mounting foot. Solenoid coils in both types are easily removable and replaceable. **Clippard Instrument Laboratory Inc.**, 7390 Colerain Rd., Cincinnati 39, Ohio. G

Circle 644 on Page 19

V-Belt Drives

have interchangeable, quick-detachable bushings



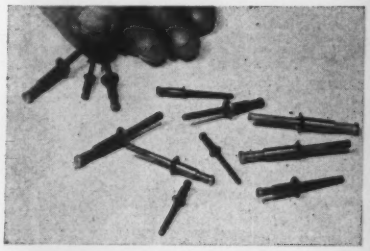
Q-D-V standard V-belt drives can be mounted easily on shaft and removed for maintenance. Fixed-pitch, standard-sheave drives incorporate interchangeable, quick-detachable bushings. QD bushings for standard A, B, C, and D cross-section belts are interchangeable with QD bushings used on larger sizes of new V-belt drives. Sheaves are interchangeable with a wide range of equipment drives such as conveyor pulleys, fan drives, sprocket drives, couplings, and timing belts. Q-D-V drives handle any power requirements from 1 to 1500 hp with speed ratios up to 8.55:1. **American Pulley Co.**, 4200 Wissahickon Ave., Philadelphia 29, Pa. E

Circle 645 on Page 19

Blind Rivet

for use at temperatures to 1000 F

Lock-spindle blind rivet, designated MLS, is a factory-assembled, three-piece fastener consisting of Monel



sleeve, pin of 17-4PH stainless-steel alloy, and Monel locking collar. It is produced in ⅛, 5/32, and 3/16-in. nominal sleeve diameters. Head styles are protruding (AN 470 rivet head), and 100-deg AN 427 countersunk. All sizes are available in 1/16-in. grip (sleeve length) increments, marked on every fastener. Fastener, developed for use in stainless-steel and high-alloy applications, provides corrosion resistance and exceptional strength at temperatures to 1000 F. Rivet is installed with standard Model 200 Pneu-Hydra tool. **Huck Mfg. Co.**, 2480 Bellevue Ave., Detroit 7, Mich. H

Circle 646 on Page 19

High-Temperature Solenoid

operates continuously at 1000-F temperature

Use of a new method of coil and bobbin manufacture permits solenoid to operate continuously at ambient temperatures to 1000 F. Device is intended for aircraft and missile applications where engine or re-entry temperatures render ordinary solenoids inoperative. Solenoid is designed for strokes from 0.01 to 0.06 in. At 0.01-in. stroke and 1000-F temperature, solenoid provides a minimum force of 15 lb. It requires a power source of 18 to 30 v dc. Coil resistance at 1000 F is 35 ohms. Solenoid is available with standard mountings, or with special mounting configurations to meet specifications.

Another PLUS value...

HANDLES BILLIONS SAVES MILLIONS

That's the record piled up by Rex, the *original* TableTop chain. In breweries, food processing plants and packaging handling operations, it has handled *billions* of containers...saved *millions* in man-hours, money, materials and maintenance.

TableTop is simplicity itself...just a one-piece platform link and pin. Smooth, beveled link edges assure tip-free transfers. Mail the coupon.

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(In Canada: CHAIN Belt Canada Ltd., 1181 Sheppard Ave. East, Toronto)

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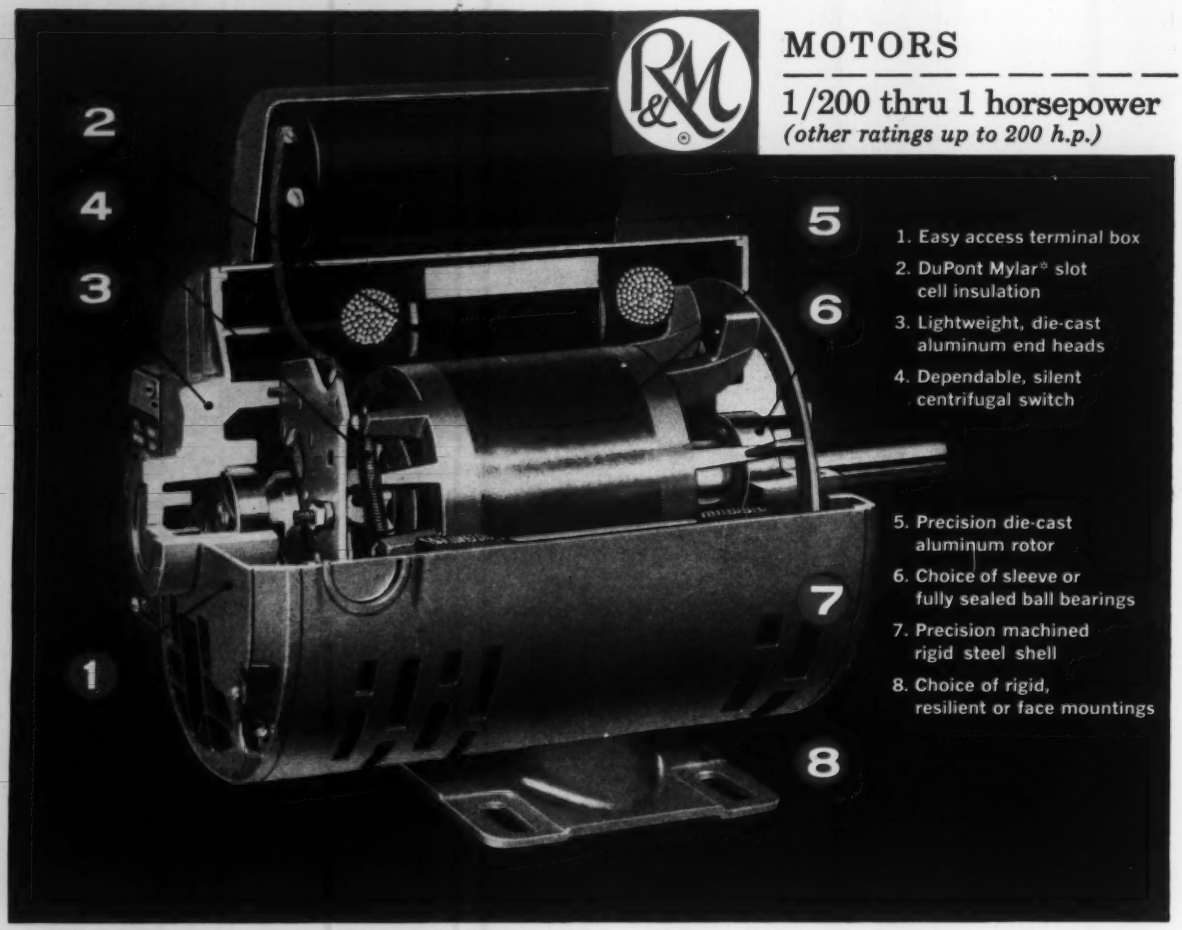
Company.....
Address.....
City.....*Zone*.....*State*.....

Circle 519 on Page 19

Another PLUS value...


MOTORS
1/200 thru 1 horsepower
(other ratings up to 200 h.p.)
1. Easy access terminal box
2. DuPont Mylar* slot cell insulation
3. Lightweight, die-cast aluminum end heads
4. Dependable, silent centrifugal switch
5. Precision die-cast aluminum rotor
6. Choice of sleeve or fully sealed ball bearings
7. Precision machined rigid steel shell
8. Choice of rigid, resilient or face mountings

R & M Fractional Horsepower Motors are packed with *Competitive Advantages* for your product!

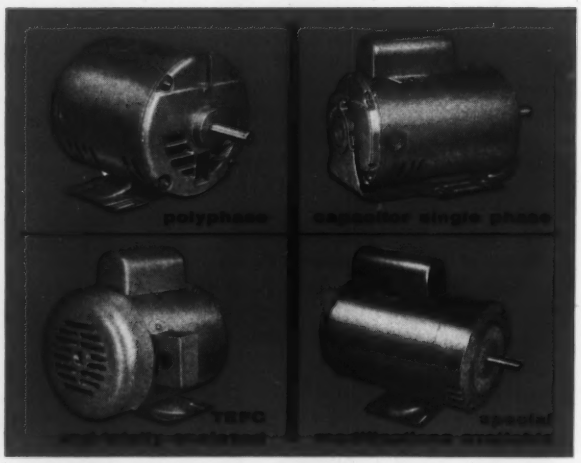
ROBBINS & MYERS "Model R" fractional HP motors, available in NEMA frames 56 and 48, are engineered and manufactured to give your product every possible competitive advantage so far as power is concerned. Each design detail results in superior performance and long trouble-free life, even under the severest operating conditions. They are smaller due to a more efficient ventilating system and lighter because of new applications of aluminum, steel and copper.

You have wider design versatility too, because they are available off-the-shelf in a broad choice of bearings, mountings, ratings, speeds and electrical characteristics.

These up-to-date design features, coupled with careful quality control at each manufacturing step, give you a modern motor you can rely on for all your powering needs. Also, if your needs indicate a custom designed motor Robbins & Myers welcomes the opportunity to discuss your quantity requirements.

Learn all about the many advantages R&M motors offer you by writing today for Bulletin 450 MD

*DuPont registered trademark



ROBBINS & MYERS, INC.

motors, household fans, Propellair industrial fans, hoists, Moyno industrial pumps

SPRINGFIELD, OHIO • BRANTFORD, ONTARIO

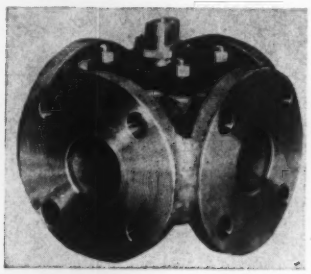
Diameter of the unit is 1⅞ in., and it weighs 1.3 lb. **Rocker Solenoid Co.**, Dept. 5206, 140 N. Marine Ave., Wilmington, Calif. M

Circle 647 on Page 19

Plug Valves

stainless-steel units have Teflon sleeves

Four and five-port Tufline stainless-steel plug valves are suited for a wide range of services. Incorporating Teflon sleeves which require no lubrication, valves are available in 150-lb class from ½ through 2-in. sizes, with both flanged ends and screwed ends. Internal ribbed construction locks sleeve in position and allows for sleeve expansion and contraction without leakage. Sleeve wiping action keeps plug free of adhering solids and liquids. Valves provide satisfactory service over



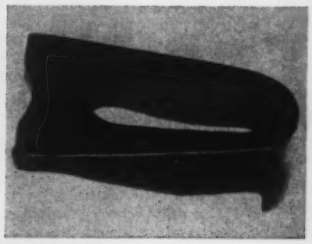
−150 to +400 F temperature range, and pressures from high vacuum to 275 psi, depending upon temperature. Valves have bodies and plugs of 316 stainless and Alloy 20, or carbon-steel bodies with 304 stainless plugs. They are also available in aluminum, bronze, Hastelloy, monel, nickel, and 304 stainless. **Continental Mfg. Co.**, 247 Park Ave., New York 17, N. Y. D

Circle 648 on Page 19

Servo-Component Clamp

is constructed of 18-8 corrosion-resistant steel

No. 2014 clamp is available for mounting motors, potentiometers, synchros, and other types of servo components. Clamp is available in two sizes to accommodate a broad range of rotating-shaft units. Slotted design provides easy engagement and broadens area in which hold-down screw may be placed. Wedge shape and use of 18-8 corrosion-resistant steel provide high holding



capacity. Unit meets requirements of MIL-E-5400. **Precision Mechanisms Corp.**, 577 Newbridge Ave., East Meadow, N. Y. D

Circle 649 on Page 19

Silicone Rubbers

sponge compounds resist temperature extremes

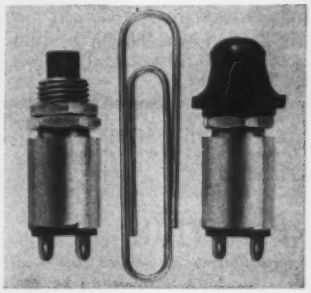
RTV silicone rubbers are sponge compounds designed for applications such as void filling, cushioning, and vibration damping. Both compounds cure at room temperature in a few minutes to form a resilient, silicone-rubber sponge. Compounds provide excellent resistance to temperature extremes, weather, ozone and sunlight, and are particularly suitable for a number of military and electronic applications. Primary difference between them is degree of resiliency. RTV-160 is designed for applications requiring greater resiliency than offered by RTV-120. **Silicone Products Dept., General Electric Co.**, Waterford, N. Y. C

Circle 650 on Page 19

Miniature Switches

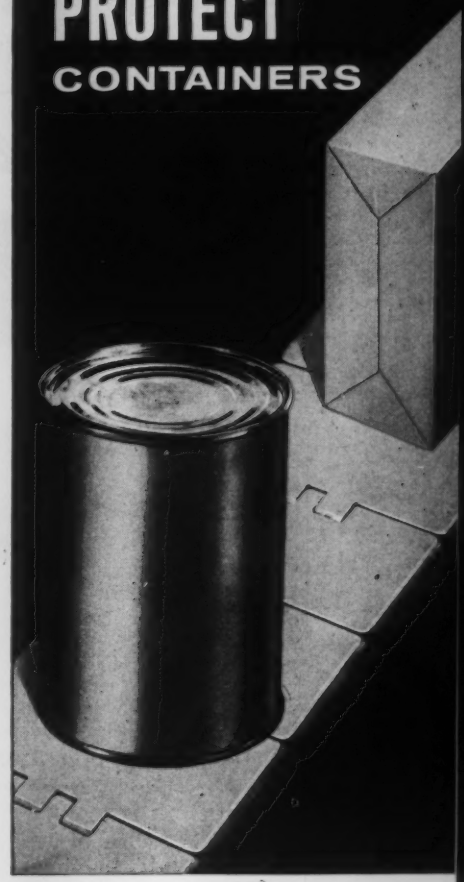
are pushbutton, snap-action type

Housed in an anodized aluminum case, tiny snap-action switches have broad application where space and weight are critical. Mounting by means of a ¼-40 threaded bushing,



Another PLUS value...

IT'S NYLON TO PROTECT CONTAINERS



Rex Nylon TableTop Chain is easy on containers because *it operates without lubrication.* No lubricant stains to soil containers...no "wearing" metal-to-metal contact when handling cans!

Nylon TableTop is smooth in operation. It's quiet...easy to assemble... stays cleaner and is easy to clean. For complete information, mail the coupon.

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NYLON TABLETOP®

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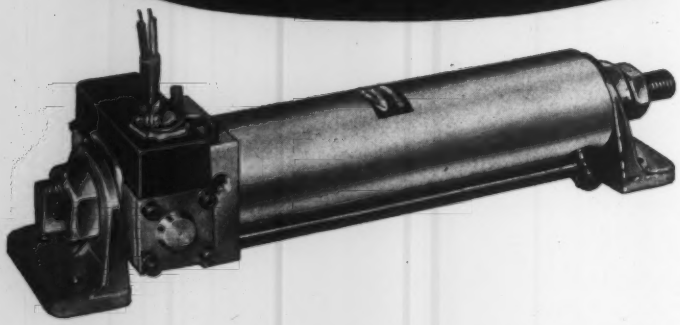
Circle 521 on Page 19

Now-SAVE SPACE, WEIGHT & PIPING

with **NEW**

Modernair
Trademark

VIH (VALVE-IN-HEAD) CYLINDERS



Here's a combination that's hard to beat—a performance-proved industrial air cylinder with its own built-in directional and exhaust speed control valves—in a single, compact "package". Check these important features:

- **BUILT-IN DIRECTIONAL CONTROL VALVES...** your choice of four control combination; double solenoid, single solenoid with button bleeder return, double button bleeder, or double remote pilot pressure operation.
- **BUILT-IN EXHAUST SPEED CONTROLS** with automatic Nylon lock.
- **INTERCHANGEABLE MOUNTINGS...** front or rear flange, low or high "L" foot brackets, rod and cylinder clevis.
- **SINGLE CONDUIT CONNECTION** for double solenoid unit.
- **AVAILABLE WITH CUSHIONED STOP** either or both ends.
- **PERFORMANCE-PROVED MODERNAIR CONSTRUCTION**

Condensed Specifications

DIAMETERS: 1½", 2", 3"
ROD SIZES: ½", ⅝", ¾"
MIN. OPERATING PRESSURE: 20 p.s.i.
SOLENOID POWER REQUIRED: 10 watts
MAX. OPERATING PRESSURE: 150 p.s.i. (solenoid) 200 p.s.i. (bleeder or pilot pressure)
SOLENOID COILS AVAILABLE: (ac) 8-10, 110, 220 v. (dc) 12, 24, 30 v.

Call your local MODERNAIR sales outlet (see Modernair trademark under "CYLINDERS" in the yellow section of your phone book) or write us today for complete data bulletin; please address Dept. E-8.

Modernair **CORPORATION** 37
400 Preda Street · San Leandro, Calif.
5007 Brookpark Rd., Cleveland 34, Ohio

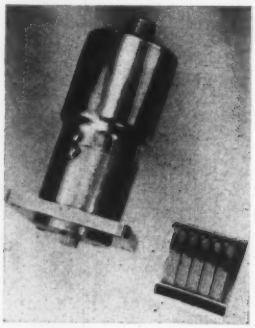
switches have a diameter of 11/32 in. and over-all length of 1 1/64 in. Pushbutton units handle 2 amp at 28 v dc or 120 v ac with minimum life of 25,000 operations. Plunger-cap color is optional. For additional protection against moisture, silicone-rubber boot for capping plunger can be supplied. **Hetherington Inc.**, 1420 Delmar Drive, Folcroft, Pa. E

Circle 651 on Page 19

Reversible Shunt Motor

has three lead connections

Model 74-015 reversible shunt motor is a small, versatile unit capable of maximum stability of speed under varied load. Motor is presently available at speeds to 25,000 rpm



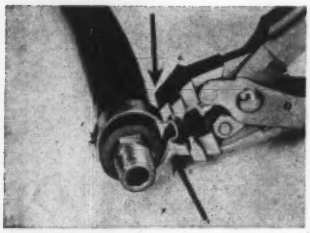
and torques to 2000 oz-in. Motor responds rapidly to varied torque loading through a temperature range of −65 to +450 F. Equipped with three lead connections, motor offers infinite variations in motor characteristics, such as high speed/low torque, or low speed/high torque. Motor characteristics can also be varied in the same direction. **Hydro-Aire Co.**, 3000 Winona Ave., Burbank, Calif. L

Circle 652 on Page 19

Hose Clamp

is one-piece, single-lug unit

One-piece hose clamp, designated Mechanical Loc Circle Clamp, is designed specifically for automotive and appliance industries or wherever low-pressure hose and tubing are used. It incorporates only one U-shaped locking lug, resulting in greater setting speed on assembly



line. Single lug can be locked quickly and easily, and clamp works equally well on rubber or synthetic hose. Clamp has a bright, electrocyanide zinc finish and is available in 15 standard sizes from 0.42 to 1.22 in. ID. **Circle Clamp Div., Cuyahoga Products Corp.**, 10252 Berea Rd., Cleveland, Ohio. G

Circle 653 on Page 19

Shaft-Locking Devices

for bushing-mounted controls

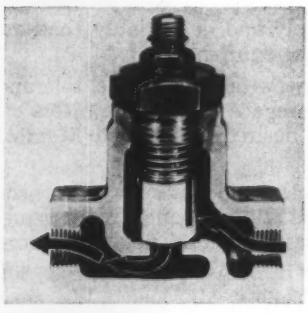
Line of shaft-locking devices consists of variations of popular shaft locks, and tapered, acorn, and jam nuts. Units are available for bushing-mounted controls with 1/4-32 or 3/8-32 threaded bushings. Material is brass plated to government specifications. **Waters Mfg. Inc.**, Wayland, Mass. B

Circle 654 on Page 19

Speed-Control Valve

uses poppet instead of needle-style control

Speed-control valve uses a poppet with four varied-length orifices instead of needle-type control. Varied lengths of four orifices permit accurate adjustment of exhaust air flow from zero to full pipe capacity. For pressure air, poppet lifts off seat, permitting unrestricted full-pipe-capacity air flow. Buna-N seat on poppet provides positive seal and eliminates wear. Lock nut on stem assures positive locking of adjusting stem. Valve is self-cleaning



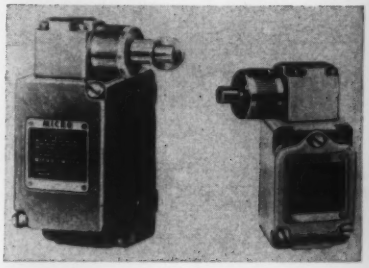
with a wiping action so that dirt does not clog and change setting. **Automatic Valve Co.**, 37415 Grand River, Farmington, Mich. H

Circle 655 on Page 19

Actuator Switches

are oiltight, side-plunger types

Side-roller plunger and plain-side plunger actuators are available in four models for use with LS and 200 LS switches. Actuator designs provide compact switches that can "lie down" in close quarters under cams and slides. Slide-roller plunger type (left) is useful for actuation by fast cams and slides. Side-plunger unit (right) has use where actuating motion is in line with plunger travel or with slow-moving cams



and slides. Actuator heads of switches can be mounted in four positions, 90 deg apart. Rollers on roller-plunger switches can be rotated 360 deg, positively locking in any position. **Micro Switch Div., Minneapolis - Honeywell Regulator Co.**, Freeport, Ill. K

Circle 656 on Page 19

AC Timing Motors

are compact, reversible units

Series 26100 ac timing motors, suitable for both military and industrial applications, have built-in gear trains offering speeds from 450 rpm down to 1/4 rph. Motors are applicable where ease of reversing is main requirement, and where small size and light weight are necessary. Synchronous characteristic of hysteresis-type motors assures accuracy on same order as power source. Operation of the reversible units can be on single or two-phase supplies. Reversing is accomplished rapidly and conveniently with a single-pole,

Another PLUS value...

PREMIUM CHAIN
...NO EXTRA COST

Rex Roller Chains are designed to give you longest possible wear life. For example, as shown above, all standard roller chains have oil holes in the bushings to assure easy penetration of life-adding lubricant to the important pin-bushing contact area...a vital factor, particularly on high-speed drives. You get many more cycles of wear life...a PLUS VALUE premium chain at no extra cost. For complete information, mail the coupon.

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Circle 523 on Page 19

For functions of rotating speed . . .

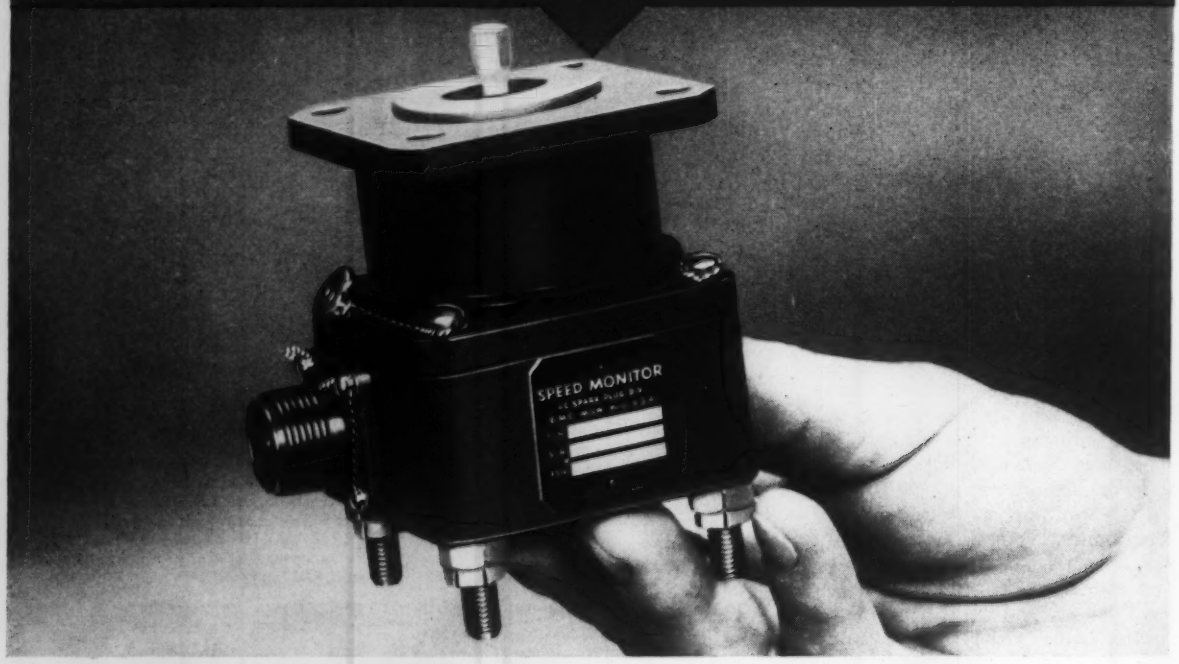
CONTROL

with the new AC Speed Monitor!

APPLICATIONS

- *Engine starting cycle control*
- *Ignition and ignition cut-off*
- *Engine starter cut-off*
- *Clutch control*
- *Entrance guide vane positioning*
- *Bleed valve control*
- *Overspeed protection*
- *Underspeed protection*

AC SPARK PLUG ⚛ THE ELECTRONICS DIVISION OF GENERAL MOTORS

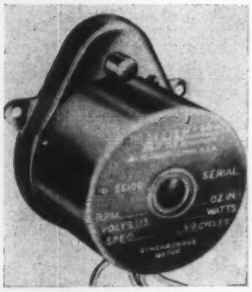


The AC Speed Monitor triggers engine and machine functions more accurately and dependably than any device now on the market. And it's applicable to both military and industrial equipment.

It's so sensitive that it opens and closes electrical contacts in two snap-action switches within a tolerance of ½% of speed settings. The speed range is 500 to 5000 rpm. Within that range AC Speed Monitors can be calibrated to your exact requirements. When more than two switches are desired, AC Speed Monitors can be coupled in tandem.

All of this performance is designed into a one-pound package that's less than three inches in any dimension — for mounting almost anywhere. Yet the AC Speed Monitor is ruggedly built and permanently lubricated for thousands of hours of life, proved by severe laboratory environmental tests and actual field conditions.

If you have need for this superb automatic device, and wish more details about it, or AC Fuel Controls, contact the Director of Sales, **AC Spark Plug—the Electronics Division of General Motors, Milwaukee, Wisconsin.**



double-throw switch. **A. W. Haydon Co.**, 232 N. Elm St., Waterbury, Conn. B

Circle 657 on Page 19

Silicon Cartridge Rectifiers

operate at altitudes to 90,000 ft

Silicon cartridge rectifiers cover peak inverse voltage range from 600 to 10,000 v. Rectifiers are ceramic-encased to prevent surface creepage and minimize flashover problems encountered in high-altitude operation. Units tested to 90,000 ft simulated altitude operated at 1600 v with no evidence of corona. Designated JEDEC types 1N2373 through 1N2381, the hermetically sealed units provide dc output currents from 75 to 250 ma at 25 C. They have an operating temperature range from −55 to +150 C, and have wide application in radar power supplies, high-voltage bias supplies, and airborne and missile instrumentation where miniaturiza-

tion, high temperature, and high-altitude operation are called for. **International Rectifier Corp.**, 1521 E. Grand Ave., El Segundo, Calif. L

Circle 658 on Page 19

Filter Element

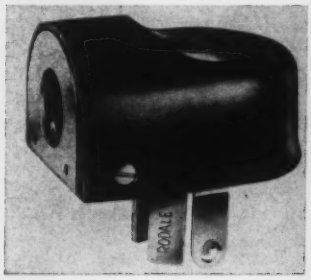
of porous ceramic has high heat resistance

Made from glass fused under controlled conditions of temperature and pressure, porous ceramic filter element has exceptionally high resistance to heat, heat shock, and chemical attack. Designed primarily for microfiltration of corrosive and high-temperature liquids and gases, element gives particle retention up to 98 per cent for each rated density. Filters are currently available in 1, 5, 10, 25, 50, and 100-mu particle-retention ratings. Elements withstand up to 600 psig differential pressure, and are easily cleaned for restored efficiency. Filter tubes are available in 10 x 2½, 20 x 2½, and 30 x 2½-in. sizes. They are also provided as discs, sheets, and cylinders of other sizes. **Commercial Filters Corp.**, 2 Main St., Melrose, Mass. B

Circle 659 on Page 19

Angle Caps

permit cables to lie in direct line with connection



Heavy-duty 30 and 50-amp, 90-deg angle caps allow cables to lie in direct line with connection. Both 30 and 50-amp units feature all-rubber bodies which withstand breakage and chipping, even under high impact. Both incorporate solderless pressure-plate terminals to speed installation time. The 30-amp unit has L-blade arrangement, and 50-amp cap has straight-blade arrangement. **Rodale Mfg. Co. Inc.**, Emmaus, Pa. E

Circle 660 on Page 19

Miniature Rotary Switches

have dual concentric shafts

Miniature, instrument-quality rotary switches are available for use in instruments, computers, and other commercial and military equipment. Total of eight switch decks can be ganged, with inner shaft controlling up to four of the eight decks. Versatile design makes it possible to combine two separate and entirely different switching ac-

Another PLUS value...

STAMINA
AT ANY ANGLE

Under loads or shocks from any angle, whether radial, thrust or combined loads, Shafer Self-Aligning Roller Bearings always retain their high load capacity. Add misalignment and the load still remains safely on the roller centers reducing retainer wear, increasing bearing life. Why? Shafer CONCAVE roller and true sphere race design—proved longer lived in thousands of installations. See your nearby distributor or mail coupon.

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☐ Please send latest Shafer Roller Bearing Catalog.
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Name.....
Company.....
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City.....*Zone*.....*State*.....

Circle 525 on Page 19

ANOTHER DRIVE-LINE PROBLEM

Photo courtesy of Reed Rolled Thread Die Co.

with APEX COVERED UNIVERSAL JOINTS

The Apex *covered* universal joints installed on the Reed Model B-111 Thread Rolling Machine serve two purposes:

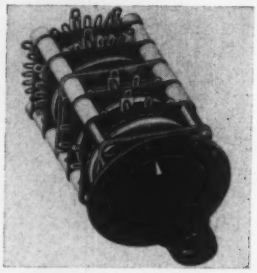
1. The pre-lubricated, sealed covers on all six universal joints insure the clean, sustained lubrication necessary for extended, trouble-free service;
2. The covers protect the joints against the deteriorating action of abrasives and oils that may develop on this type of application.

The *covered* universal joint—an exclusive Apex development—can operate efficiently in water, gases, corrosive liquids, dust- or abrasive-laden atmospheres, and in extremes of temperatures.

Apex *covered* universal joints have solved many difficult drive-line problems—and could solve yours. Write, on your company letterhead please, for Catalog 28 and our Universal Joint Application Data Sheet.

THE APEX MACHINE & TOOL CO. 1042 South Patterson Blvd. DAYTON 2, OHIO

Phantom view of APEX covered universal joint which operates efficiently in wet or dry, corrosive or abrasive atmospheres, and in extremes of temperatures.



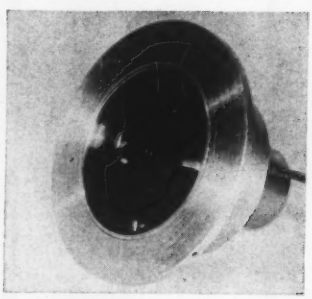
tions on two concentric shafts, with many combinations possible. In addition, 1/8-in. diam inner shaft can also be used to operate other devices such as rheostats, potentiometers, or condensers. Multileaf wipers, silver-alloy button contacts staked in glass-epoxy decks, nylon bushings, and salt-spray-resistant hardware assure stable contact resistance of less than 0.002 ohm for better than 10,000 operations. **Shallcross Mfg. Co.**, Selma, N. C. A

Circle 661 on Page 19

Miniature Fan

produces 45 cfm air at 17,000 rpm

Miniaturized fan is designed specifically for electronic or avionic applications. Powered by a 28-v dc motor, it produces 45 cfm air at 17,000 rpm. Unit measures less than 2 in. diam and 2 in. long, and is



identified as Model F2-17. **Electro Products Div., Western Gear Corp.**, 132 W. Colorado Blvd., Pasadena, Calif. L

Circle 662 on Page 19

Air Poppet Valve

opens and closes only when plunger is compressed

Pulse-Air poppet valve is primarily for use as an energizing medium for pilot-operated air-control valves.

Circle 526 on Page 19

Valve can be actuated by hand or by some mechanical means, either direct or remote. Function is to release a measured amount of air from pilot chamber of air-control valve. Static pressure balance is upset, causing movement of valve spool which changes directional flow through control valve. Valve opens and closes only when plunger is compressed, making it unnecessary to decompress plunger before control valve is energized in opposite

direction. **Savage Engineering Div., Lithibar Co.**, 345 W. 14th St., Holland, Mich. H

Circle 663 on Page 19

Thermocouple Tubing

magnesia tubing is available in small sizes

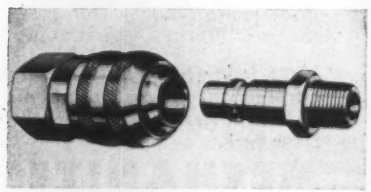
Two-hole thermocouple tubing is the smallest of a new line of magnesia tubes. High-purity formula limits content of boron to 8 parts per million. Tubing is produced for swageable thermocouples such as are being used in the nuclear field, in jet engines, the oil industry, and for other critical applications where extra-long thermocouples are desired. Two sizes are 0.030 and 0.055 in. OD, with 0.006 and 0.007-in. ID twin holes, respectively. Tolerance of ±0.0015 in. is consistently maintained. **Saxonburg Ceramics Inc.**, Saxonburg, Pa. F

Circle 664 on Page 19

Air-Hose Coupling

for ¼, ⅜, ½, and ¾-in. ID hose

Flex-O-Matic coupling requires no tools to couple or uncouple. Straight



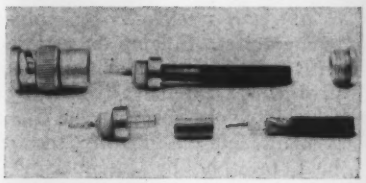
push connects plug, locking it firmly in socket regardless of air pressure. Slight pull on knurled sleeve disconnects socket and plug, automatically shutting off air. Precision-fitted seal prevents leakage, and swivel action of plug in socket prevents kinking of hose. Air passage through coupling is unrestricted, assuring maximum air flow and economical use of compressed air. Coupling is available in four sizes for ¼, ⅜, ½, and ¾-in. ID hose. **Lincoln Engineering Co.**, 4010 Goodfellow Blvd., St. Louis 20, Mo.

Circle 665 on Page 19

Coaxial Plug

is quick-assembly type

BNC coaxial plug uses a crimping technique to attach outer cable braid to plug. Quick-assembly design minimizes number of parts to be handled. Plug can be taken apart quickly for visual inspection, provides confined contact, and mates with all standard BNC plugs and



jacks. To assemble cable to plug, a ferrule is slipped over juncture of cable and plug, and crimping pressure is applied with a preset crimping tool. Center conductor of RF cable is soldered to plug in normal manner. **Cannon Electric Co.**, 3208 Humboldt St., Los Angeles 31, Calif. L

Circle 666 on Page 19

Electrical Connectors

provide maximum contacts in minimum space

Multiple-contact plugs and sockets provide easy engagement and disengagement, with simple, positive lock holding them together. When lock is released, units separate by spring action of contacts. Plugs and connectors offer maximum number of contacts in minimum space. They are available with 20 to 100 contacts in multiples of 10 contacts. They can also be sup-

Another PLUS value...

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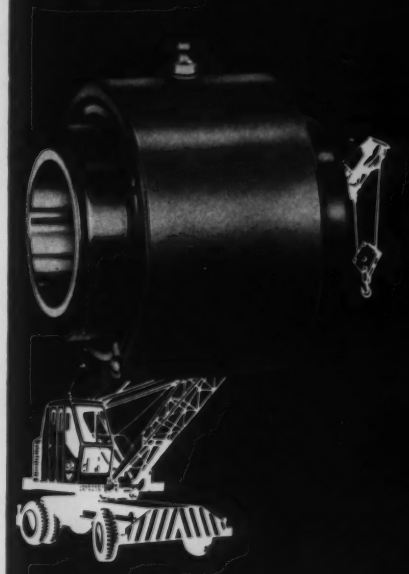

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High load capacity of a roller

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Circle 527 on Page 19

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NOW test both compression and extension springs on one compact spring tester — the Chatillon MST. Test *all* your springs with the MST — it's faster, easier and a lot more accurate.

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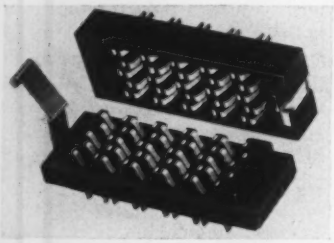
Circle 528 on Page 19



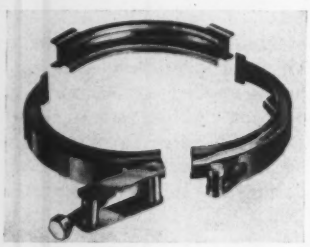
plied with caps and cable clamps, and are rated at 4½ amp. Cinch Mfg. Co., 1026 S. Homan Ave., Chicago 24, Ill. J

Circle 667 on Page 19

Breakaway Clamp

is unaffected by ambient temperatures

Quick-disconnect breakaway clamp adaptable to remote actuation is used to connect tubes carrying fuels and liquids between stages of missiles and between airplane wings and jettisonable wing-tip tanks. Manufactured in stainless steel, clamp is ¾ in. wide and is available in diameters from 2½ to 6 in. It is unaffected by ambient temperatures. Clamp is equipped with a hole for attaching a lanyard which can be activated by a solenoid or electronic device. Clamp is manufactured in three sections, held together by interlocking T



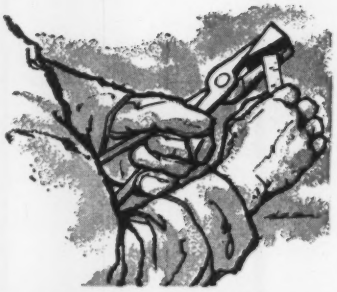
and U-joints which unhook as pressure is released with activation of lanyard. Awica Clamp Div., Poly Industries Inc., Pacoima, Calif. L

Circle 668 on Page 19

Centrifugal Pump

entire assembly is corrosion resistant

Centrifugal pump consists of two metal stampings bolted together to form a housing which encloses a welded impeller assembly. Smooth interior surfaces give high-efficiency flow. With same basic pump cas-



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Barnett Foundry & Machine Co., Irvington, N. J.
Blackmer Pump Co., Grand Rapids, Mich.
Centrifugally Cast Products Div., The Shenango Furnace Co., Dover, Ohio
Compton Foundry, Compton, Calif.
Continental Gin Co., Birmingham, Ala.
The Cooper-Bessemer Corp., Mt. Vernon, Ohio and Grove City, Pa.
Crawford & Doherty Foundry Co., Portland, Ore.
Dayton Casting Co., Dayton, Ohio
Empire Foundry Co., Tulsa, Okla. and Bonham, Texas
Florence Pipe Foundry & Machine Co., Florence, N. J.
Fulton Foundry & Machines Co., Inc., Cleveland, Ohio
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Georgia Iron Works, Augusta, Ga.
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Nordberg Manufacturing Co., Milwaukee, Wis. and St. Louis, Mo.
Palmyra Foundry Co., Inc., Palmyra, N. J.
The Henry Perkins Co., Bridgewater, Mass.
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Rosedale Foundry & Machine Co., Pittsburgh, Pa.
Ross-Meehan Foundries, Chattanooga, Tenn.
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Washington Iron Works, Seattle, Wash.
Dorr-Oliver-Long, Ltd., Orillia, Ontario
Hartley Foundry Div., London Concrete Machinery Co., Ltd., Brantford, Ontario
Otis Elevator Co., Ltd., Hamilton, Ontario

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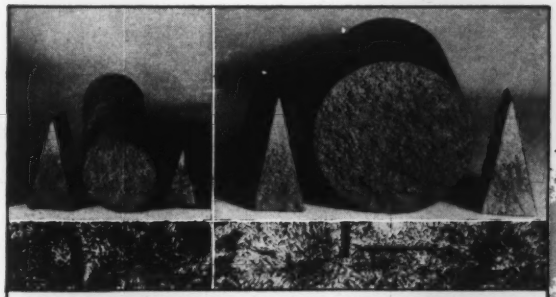
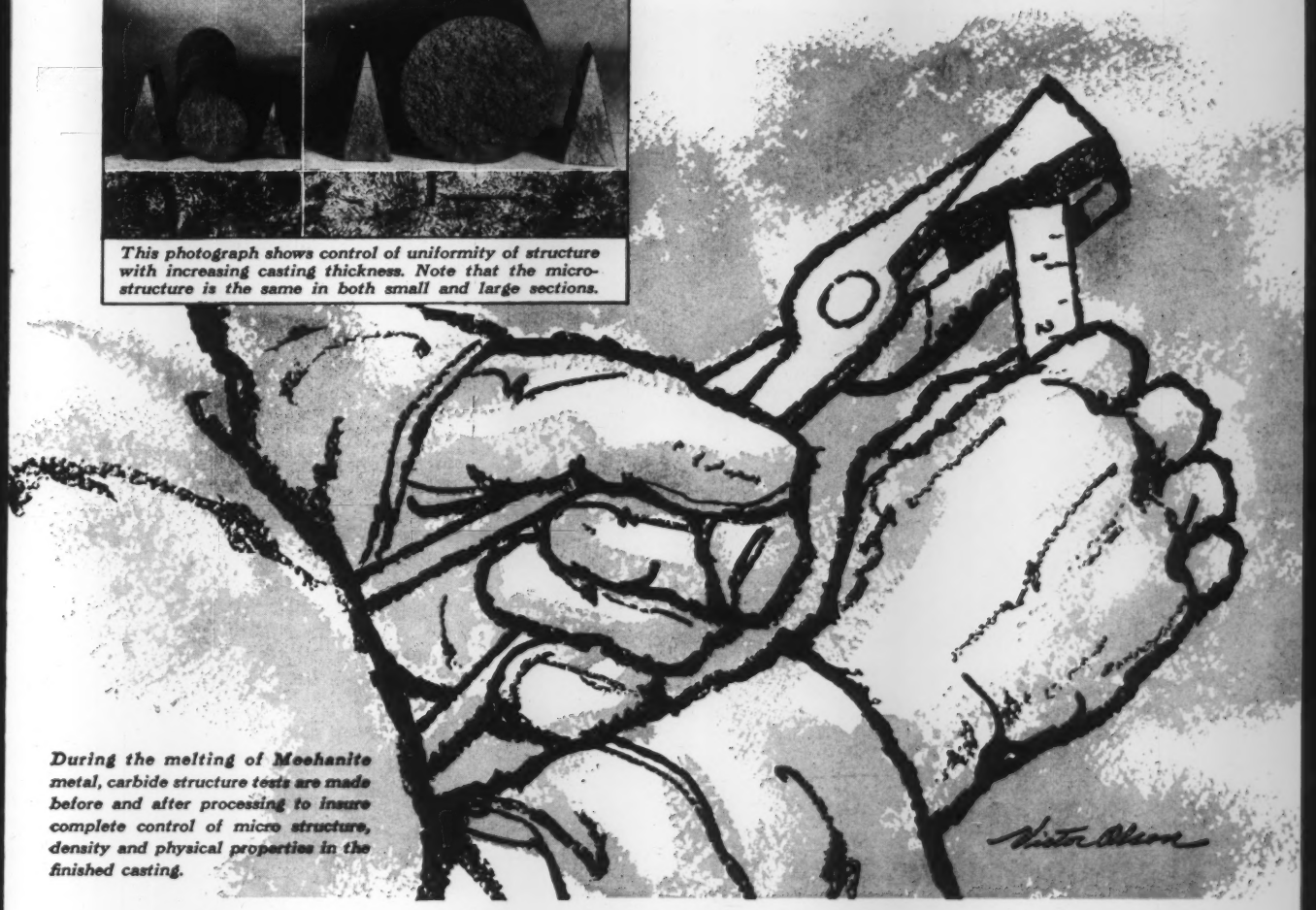
Protected by U. S. Patent: 2,371,654



This photograph shows control of uniformity of structure with increasing casting thickness. Note that the microstructure is the same in both small and large sections.



During the melting of Meehanite metal, carbide structure tests are made before and after processing to insure complete control of micro structure, density and physical properties in the finished casting.

Casting solidity and uniform properties are assured regardless of dimensions with Meehanite metal.

By the aid of a patented discovery, Meehanite® has established a means of controlling structure and mechanical properties of castings of all designs and sizes. This unique procedure is of vital significance to engineering production both in obtaining dependable castings with uniform physical properties as well as in assuring lowest costs in processing for use.

Meehanite metals' dense, fine grain structure which is independent of the mass or section of the casting, is achieved by a three-fold process which relates the carbide stability of the molten metal both before and after processing to the casting section. This process is used only by licensed Meehanite foundries throughout the world.

Meehanite metal represents the most advanced developments in the metallurgy and manufacture of castings to specified physical properties. There are more than twenty-six different types of Meehanite® available for General Engineering, Wear Resisting, Heat and Corrosion applications.

Accept no substitute for Meehanite® quality. Specify Meehanite® and be sure. There's a Meehanite foundry near you. See list on opposite page.

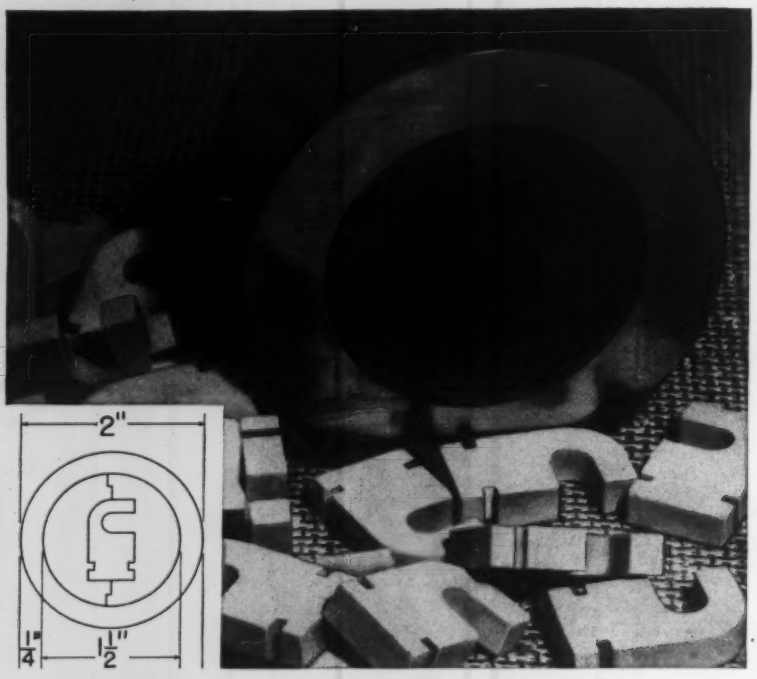
MEEHANITE BRIDGES THE GAP BETWEEN CAST IRON AND STEEL®

MEEHANITE METAL

MEEHANITE METAL CORPORATION

NEW ROCHELLE NEW YORK

Circle 529 on Page 19



Section of die used for making a ceramic component for the electrical appliance industry. One half of the dark center portion subjected to wear is made from Kennametal grade K96 . . . the other half from an "equivalent" competitive carbide.

By accident . . . this company found

There is a difference in CARBIDES

An accident that broke one section of this die gave Du-Co Ceramics Company, Saxonburg, Pa., an excellent opportunity to compare carbides. The original die was made from Kennametal grade K96 and had turned out 800,000 steatite hooks before the accident. In replacing the broken section, an "equivalent" competitive carbide was selected.

After an additional run of 200,000 hooks, the original K96 section of the die still showed no sign of undercutting from abrasion. A dull finish was the only evidence of wear . . . after 1,000,000 pieces.

The other, newer section, however, showed definite undercutting after the 200,000 run and Du-Co estimates a total of 500,000 hooks will be its maximum life.

Nine different grades are included in the Kennametal family of hard carbide compositions. There is one that will best match *your* need for long wearing dies, brick mold liners, spray nozzles, pulverizing hammers, jiggering and forming tools and other wear applications. Why not find out more about this remarkable metal with unusual resistance to abrasion and corrosion, high impact strength, and three times the stiffness of steel. Contact your Kennametal Representative, or write KENNAMETAL INC., Department MD, Latrobe, Pennsylvania, for Booklet B111A "Characteristics of Kennametal." 97217

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INDUSTRY AND KENNAMETAL ...Partners in Progress

ing, a wide range of capacities is available by varying impeller design and motor size. Entire pump assembly is resistant to corrosion. Materials include brass, Monel, and various stainless steels, with other

materials available on order. Pump is available coupled directly to motor, extended from motor flange for special heat and chemical applications, and with pump alone mounted on base for coupling to any power supply. R. S. Corcoran Co., P. O. Box 1404, Mound at Brandon, Joliet, Ill. I

Circle 669 on Page 19

Time-Delay Relays

adjustable units are subminiature

Two lines of high-reliability time-delay relays have guaranteed accuracy ratings of 10 or 5 per cent. The adjustable units meet all accuracy and reliability requirements of high-performance electronic systems, particularly for airborne and ground-support missile applications. Of subminiature size and weight, units include provision for simple, quick field adjustment of time-delay period. Six basic units are available, with overlapping time-delay ranges. Each is capable of 20:1 adjustment range as follows: 0.05 to 1 sec; 0.15 to 3 sec; 0.75 to 15 sec; 3 to 60 sec; 9 to 180 sec; 15 to 300 sec. Relays withstand vibration to 20 g at 2000

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WORM GEAR SETS

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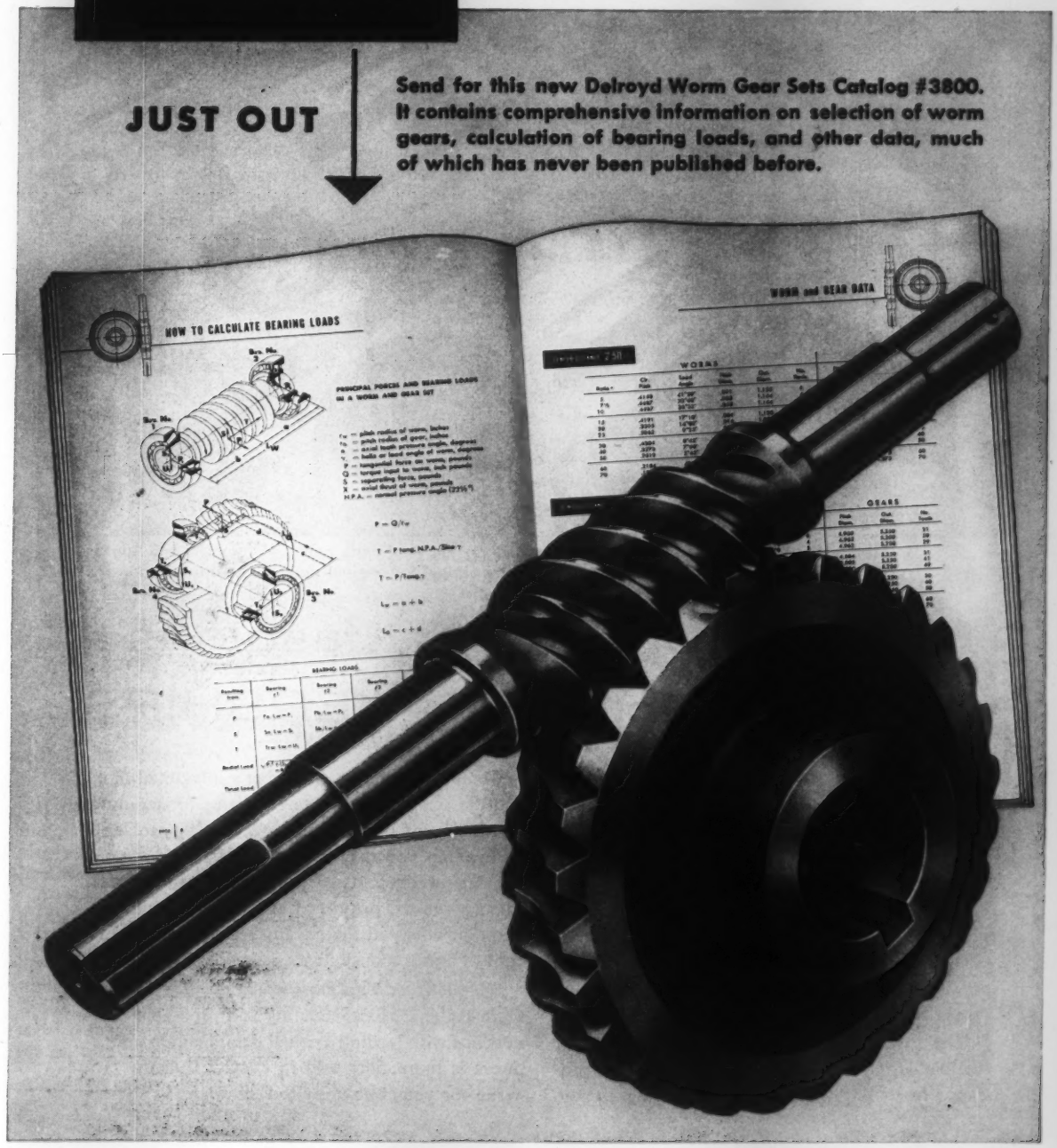
JUST OUT

Send for this new Delroyd Worm Gear Sets Catalog #3800. It contains comprehensive information on selection of worm gears, calculation of bearing loads, and other data, much of which has never been published before.



DE LAVAL *Steam Turbine Company*

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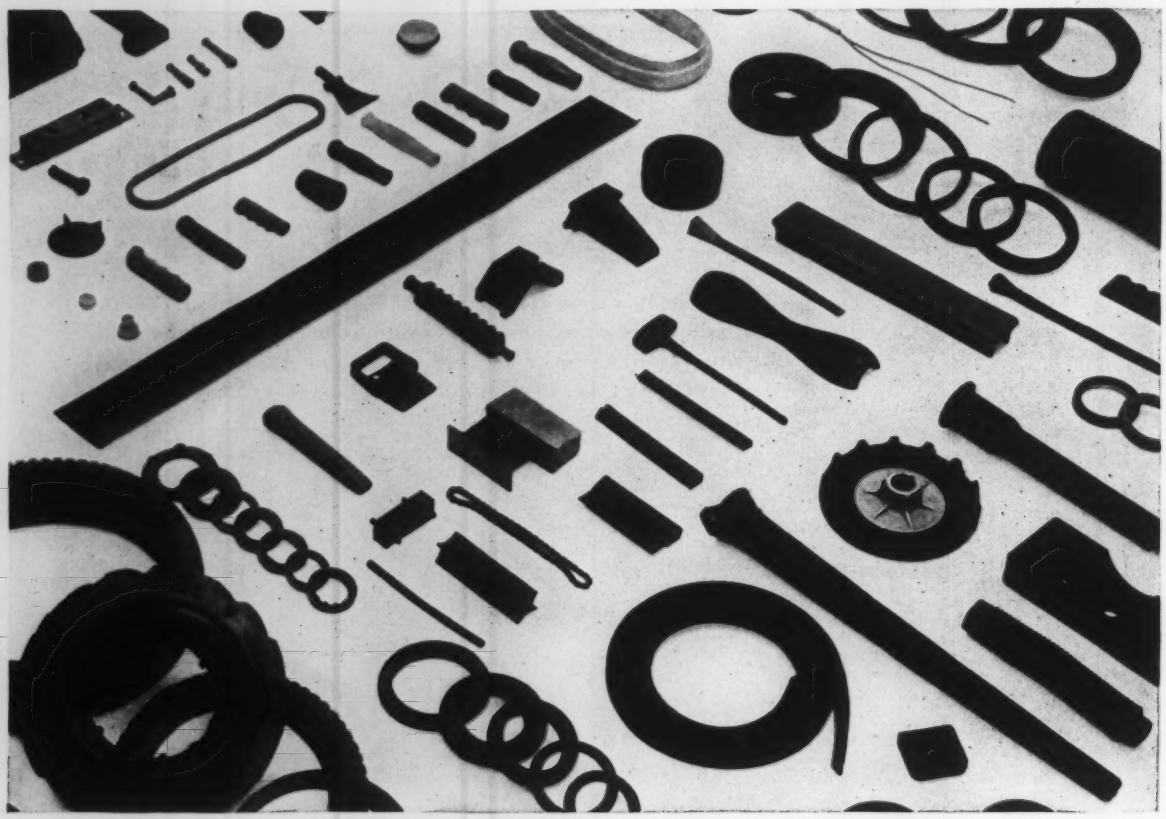
DL-459



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An Ohio Rubber "Customeering" engineer may start with your blueprint, but he begins saving you money *after* he checks your performance requirements—what you need, where and how you'll be using your component part.

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Suggestion: The more complete story behind Ohio Rubber's long-standing and profitable partnerships with leading original equipment manufacturers is more fully told in ORCO Bulletin 715. Write for your free copy today! 9MP1

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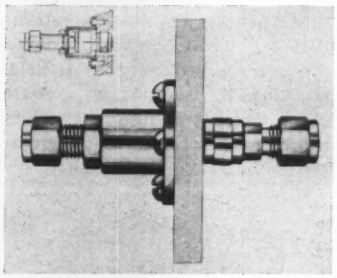
cps, shock to 50 g for 11 millisec, and acceleration to 20 g. They withstand temperatures from −55 to +125 C. **Tempo Instrument Inc.**, P. O. Box 338, Hicksville, N. Y. D

Circle 670 on Page 19

Flush-Mount Flange

for rear mounting of quick-connect fittings

Adapter unit is available for flush rear-mounting of Swagelok bulkhead quick-connect fittings on instrument panels. Application of flange permits a more uniform and attractive appearance on front of panel board, since there are no



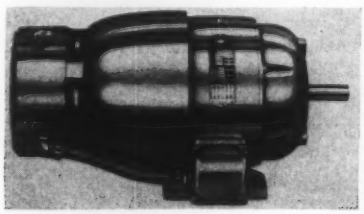
projecting parts of the quick-connect. Flush-mount flange fits ¼ and ⅜-in. Swagelok bulkhead quick-connect. **Crawford Fitting Co.**, Cleveland 10, Ohio. G

Circle 671 on Page 19

Totally Enclosed Brakemotor

in ratings from 1 to 30 hp

Totally enclosed, fan-cooled brakemotor has applications in food processing, metalworking, materials handling, and lumbering. Doughnut-type magnet in brake allows motor shaft to extend entirely through, so that same motor can have both a magnetic brake and cooling fan, totally enclosed and sealed. Use of aluminum-alloy construction keeps weight at a minimum and allows good heat dis-



ALLEN

The cost of ALLEN Hex-Socket Cap Screws is only a minor fraction of your assembly costs . . . be sure you're getting the timesaving, cost-saving advantages of genuine Allens!

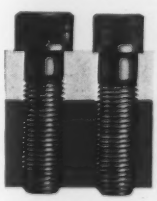
Ever since Allen first produced the hex socket head screw nearly fifty years ago, specifying *genuine* Allens (made by Allen of Hartford) has been a sure way to guarantee dependable threaded fastening.

Only *genuine* Allens have Leader Points that make starting easier, and greatly minimize danger of cross threading. *Genuine* Allens are "pressur-formd" to preserve the long fibers uncut throughout the length of the screw, giving stronger sockets for greater tightening torque.

Write for samples and engineering data. See how *genuine* Allens will make your product better.

ALLEN HEX-SOCKET SCREWS HEAD

Allen's new 1960 Series Socket Head Cap Screws give up to 2½ times more load carrying capacity, without indentation. Head diameter of sizes from ¼" up is now uniformly 1½ times the body diameter—providing more under-the-head bearing surface, and a proportionate increase in clamping force. Write for new Bulletin G-25, with full specifications.



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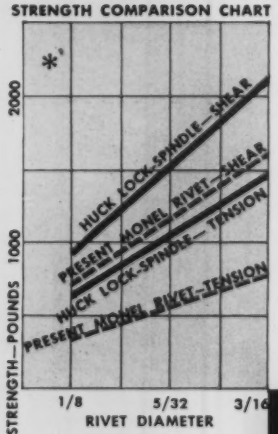
Circle 532 on Page 19

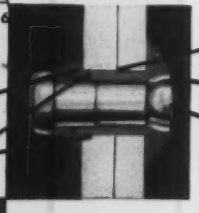
HUCK MONEL

LOCK-SPINDLE FASTENERS

- Greatly increased shear and tensile strength*.
- Requires no pin trimming.
- Positive mechanical lock.
- 1/16" grip increments (Interchangeable with MS rivets).
- 1/8, 5/32, 3/16 diameters. Protruding or countersunk head.
- Excellent strength at elevated temperatures.
- Compatible with high temperature materials.
- Strongly corrosion resistant.
- Broad blind side bearing, ideal for thin stock.
- Visual, drive side inspection.
- Fast, uniform installation (unskilled).
- Installs with standard Huck tools.
- A thoroughly proved fastener design.

STRENGTH COMPARISON CHART





Broad blind side bearing.

Extra shear strength.

Excellent pull-together and clinch.

Positive mechanical lock.

No pin trim necessary.

Representatives in all principal cities.

HUCK MANUFACTURING COMPANY

2480 Bellevue Avenue • Detroit 7, Michigan • Phone WA 3-4500

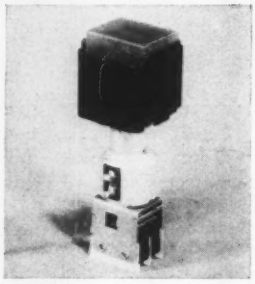
sipation. Brakemotor is available in ratings from 1 to 30 hp and frame sizes 182 through 326U. Drive motors can be standard squirrel cage, wound rotor, or Fluid Shaft. **Reuland Electric Co.**, 3001 W. Mission Rd., Alhambra, Calif. L

Circle 672 on Page 19

Panel Switch

is lighted, solenoid-held type

Solenoid-held, lighted pushbutton panel switch is designed for use on control panels which require an electrical interlock system such as used for sequence operation. It also can be used in remote-control applications to monitor operation of equipment which switch controls. Solenoid is used only to hold the circuit after switch is actuated. Switch consists of four parts: Pushbutton, made of colored plastic and heat-stamped with a legend; illumi-



nation source consisting of two 6 or 28-v lamps; double-pole, 5-amp switch; and 28-v solenoid integral with pushbutton mechanism. Entire unit requires only slightly more than 1 sq in. of panel space. **Electrosnap Corp.**, 4218 W. Lake St., Chicago 24, Ill. J

Circle 673 on Page 19

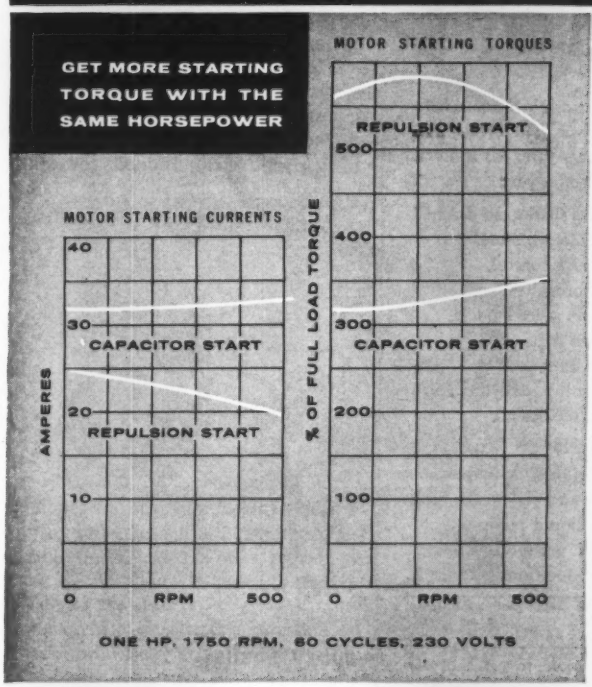
Sump-Type Filters

for use in flows from 8 to 50 gpm

Five sizes of industrial sump-type filters are available for use with hydraulic and lubricating oils, coolants, and other liquids. Series 3000 filters are designed for low-cost removal of dirt, rust, lint, and sludge in flows ranging from 8 to 50 gpm. They are equipped with standard 100-mesh Monel element for filtration to 140 mu. Filter-

TOUGH STARTS MADE EASY...

WAGNER REPULSION-START INDUCTION MOTORS



START HEAVY LOADS WITH EASE

STAND UP UNDER LONG SERVICE

USE EXTREMELY LOW STARTING CURRENT

Starting heavy loads is a natural for Wagner Type RA Motors. Widely used for high starting torque applications, like farm machinery, compressors, pumps and grinders, this rugged single phase motor requires very low starting current that minimizes light flicker. You get smooth performance with a constant high operating speed, even under overload, and a flat efficiency curve over a wide operating range.

You practically eliminate service problems when you power tough single phase applications with these motors. They have unmatched ability to start high inertia or heavy friction loads repeatedly and they give many years of unfailing service.

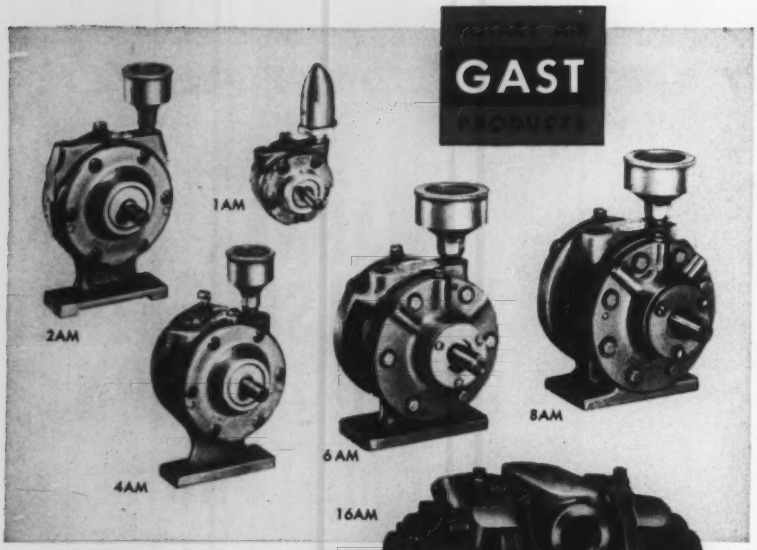
You can get these motors from leading motor distributors in your community or through Wagner Sales Offices in 32 principal cities. Your Wagner Sales Engineer will be glad to help you select the right motor for your application. Wagner Bulletin MU-220 gives full details on Repulsion-Start-Induction Motors.

WM59-8

Wagner Electric Corporation

6404 PLYMOUTH AVENUE, ST. LOUIS 14, MISSOURI

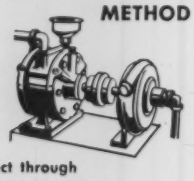
SERVING 2 GREAT GROWTH INDUSTRIES ... *ELECTRICAL* ... *AUTOMOTIVE*



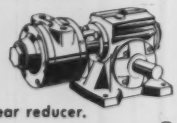
Six sizes . . .
all variable-speed
explosion-proof

GAST rotary vane AIR MOTORS

CHOOSE YOUR DRIVE METHOD



Direct through flexible coupling.



Use gear reducer.

Flange mounted – vertical operation.

Driving pulley.

Need a compact, low-cost motor for original equipment or plant use applications? *Air may be your answer . . .* using one of these efficient Gast rotary-vane Air Motors. Look at the special advantages they offer you:

1. They're explosion-proof — no sparks, no danger!
2. Low initial cost compared to other motors.
3. Speed variable with simple valve control.
4. Can't burn out if overloaded or stalled.
5. Reversible rotation optional on some models.
6. Rotor vanes take up their own wear.
7. Quickly attached to plant air lines.
8. Amazingly light, compact for h.p. delivered.
9. Ball-bearing; almost service-free design.
10. Mechanically simple, neat in appearance.

Gast Air Motors are supplied as original equipment on pneumatic hoists, mixers for paint and chemicals, fans, blowers, fuel hose-reel rewinders, liquid pumps, spooling machines and a host of other products. Used in explosive atmospheres and in "hot" locations to 250° F.

Model No.	1AM	2AM	4AM	6AM	8AM	16AM
H.P. at 90 P.S.I., 2000 RPM	0.13	0.57	1.1	2.0	4.0	7.0
Weight, lbs.	1½	5½	8	17	25	65

For complete performance data, write for Air Motor Bulletins. Specify models that interest you.

GAST MANUFACTURING CORP., P.O. Box 117-P, Benton Harbor, Michigan

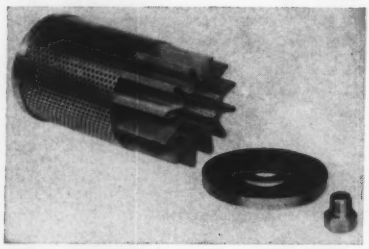
SEE CATALOG IN SWEET'S PRODUCT DESIGN FILE & A.S.M.E. CATALOG

GAST ROTARY

- AIR MOTORS TO 7 H.P.
- COMPRESSORS TO 30 P.S.I.
- VACUUM PUMPS TO 28 IN.

"Air may be your answer!"

Circle 535 on Page 19



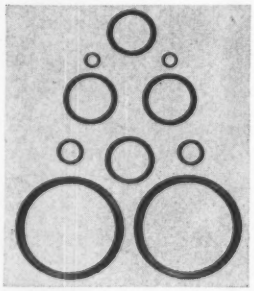
ing area ranges from 81 to 505 sq in. Steel perforated filter housing insures maximum flow with minimum restriction. Compression sealing at top and bottom assures positive seal even at highest flows. **General Filters Inc.**, 43800 Grand River Ave., Novi, Mich. H

Circle 674 on Page 19

Standard O-Rings

for use at temperatures from −320 to +500 F

Made of Rulon, a modified Teflon, standard O-rings afford high wear resistance and low coefficient of friction even under completely non-lubricated conditions. Rings are completely inert to all common fluids and can be used at temperature extremes from −320 to +500 F. Rings are recommended for static



and dynamic applications such as piston seals, valve seals, flange gaskets, and tube-fitting gaskets. **Dixon Corp.**, Bristol, R. I. B

Circle 675 on Page 19

Epoxy Shells

for encapsulating all components

Epoxide resin shells, available for encapsulating all types of components, have high tensile strength and operate to maximum temperature of 150 C. Available holes and leads facilitate assembling operations on winding forms. Low water-

B.F.Goodrich

RIVNUTS®

give casual furniture fast selling luxury look

Durham Manufacturing Corporation preserves the clean, functional lines of its modern tubular furniture with B.F.Goodrich Rivnuts. Rivnuts eliminate unsightly nuts and bolts, speed assembly, add sales appeal.

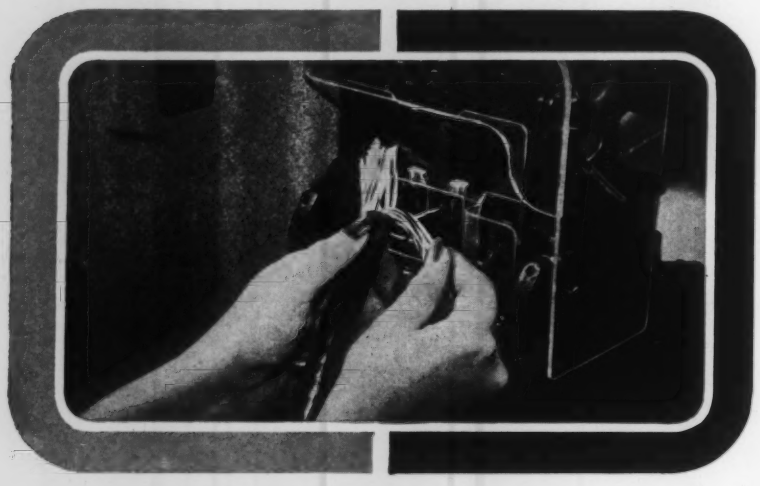
Durham switched to B.F.Goodrich Rivnuts at key points in its complete line of casual furniture, including the inviting DURelaxer above. Rivnuts with countersunk heads are upset inside the tubular legs (see drawings). They provide high-strength nutplates for unobtrusive attachment screws. Crimped, lock-type ends prevent screws from backing out.

Only B.F.Goodrich Rivnuts give you firm, blind nutplates for tubular applications. So if you want to do a smoother fastening job, or want to fasten faster and at less cost, use B.F.Goodrich Rivnuts. Send now for free data booklet. *B.F.Goodrich Aviation Products, a division of The B.F.Goodrich Company, Dept. MD-89, Akron, Ohio.*

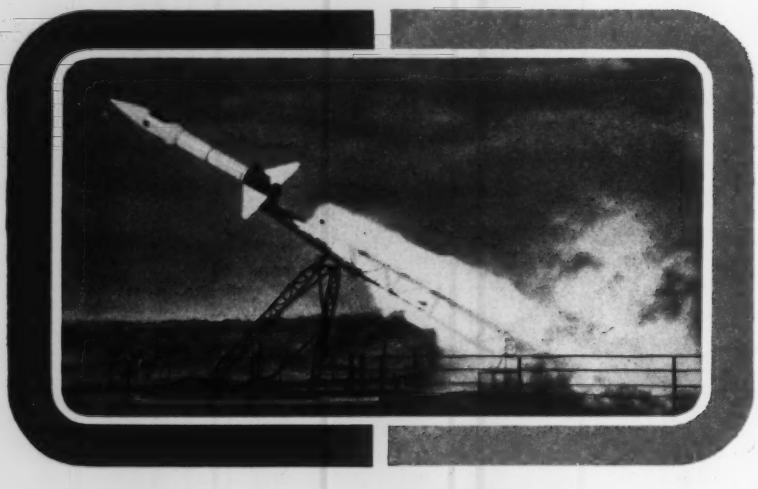
B.F.Goodrich *aviation products*

Circle 536 on Page 19

Circuit Terminations Made Here



Do Not Fail Here



Each click of the dies in this A-MP Automachine indicates the completion of another top quality termination. This completely mechanical "crimp" means that there will be no variations in quality, no failures in service. The A-MP terminal actually becomes a homogeneous part of the wire end, supporting it against vibration, resisting corrosion, and affording the soundest electrical performance.

The A-MP Automachine literally "mints" these attachments at the rate of thousands per hour . . . and at a minimum cost to you. Time and time again, AMP has proven that its method costs less and assures higher reliability than any other termination method.

Whether your problem is reliability, production volume or installated cost, AMP can help you. Why not send for descriptive literature today?

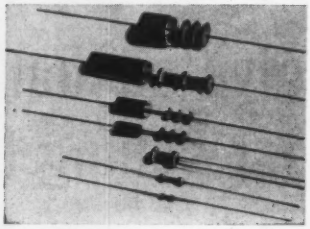
AMP INCORPORATED

General Offices: Harrisburg, Pennsylvania

A-MP products and engineering assistance are available through subsidiary companies in: Canada • England • France • Holland • Japan

Circle 537 on Page 19

absorption characteristics protect enclosed components from water and atmosphere. Sealing is accomplished with liquid epoxy resin matching material of shell. Dielectric constant is 3.7 at 60 cycles with low



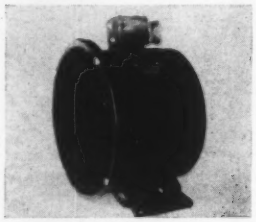
loss factor of 0.009. Variations in shapes from tubular to rectangular are furnished, and diameters range from $\frac{1}{8}$ to 1 in. and heights from $\frac{1}{4}$ in. **Thor Ceramics Inc.**, Dept. K, 225 Belleville Ave., Bloomfield, N. J. D

Circle 676 on Page 19

Vane-Axial Blower

cools electronic equipment

Model FV7-1 vane-axial blower has an output of 600 cfm at 1-in. water static pressure, and 760 cfm free air. Input is 200 v ac, 400 cps, three-phase at 1.2 amp. Blower, used to cool electronic equipment, incorporates a motor which qualifies to MIL-M-7969A. It is a six-



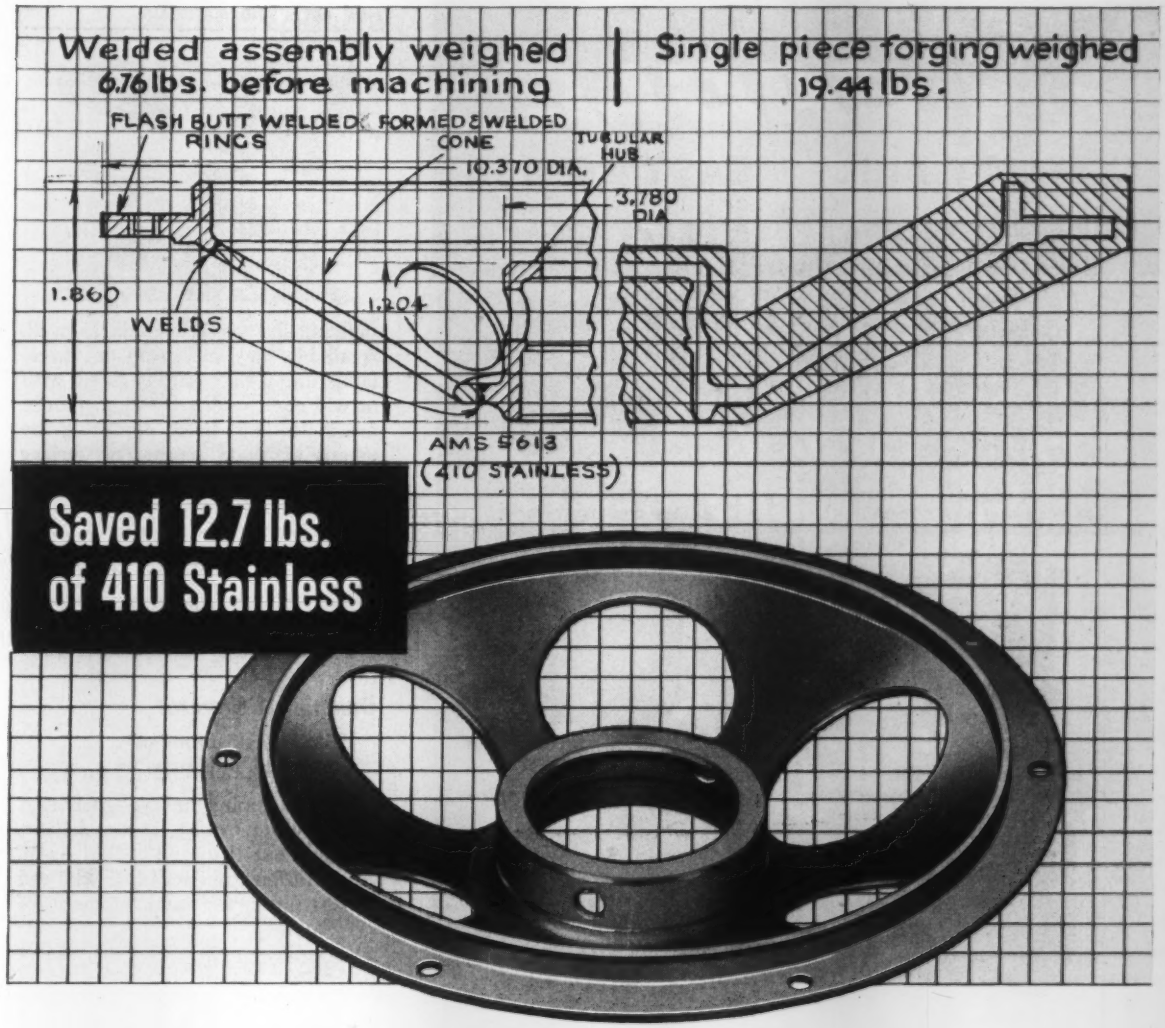
pole, 7300 -rpm unit, designed for 2000 hr of life. Motor is equipped with three-phase thermal protection for overload and stall conditions. **Electro Products Div., Western Gear Corp.**, 132 W. Colorado Blvd., Pasadena, Calif. L

Circle 677 on Page 19

Indicator Lamps

are available in one, two, and three-lamp units

SE 15, 17, and 18 indicator lamps use any standard switchboard lamp of 6, 12, 24, or 48 v, and serve as



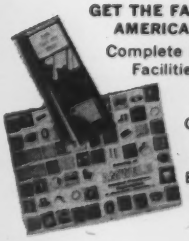
Cost of Jet Engine Component Reduced $31.21 by Flash Butt-Welded Ring Assembly

Visualizing this jet engine assembly as three simple parts, instead of a single complicated piece, was the first step in reducing its cost.

By circumferential welding, a flash butt-welded ring, a formed and welded cone, and a tubular hub were joined together. Material required was reduced 65% and hours of machining were eliminated on each piece.

This fabricating know-how has helped many companies cut the cost of circular parts and components, particularly where high-strength, high-temperature alloys are involved.

On prototype and production runs, Amweld's subcontracting service includes the assistance of experienced engineers and metallurgists. Send us prints and specifications . . . we will be happy to study your problem and perhaps suggest ways that fabrication by welding can help you reduce costs.



GET THE FACTS ABOUT AMERICAN WELDING

Complete information. Facilities brochure, Precision Assemblies Catalog, and booklet on "How Flash Butt-Welded Rings are Made."

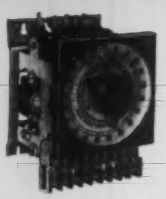
THE AMERICAN WELDING & MFG. CO. • 130 DIETZ ROAD • WARREN, OHIO

AMERICAN WELDING

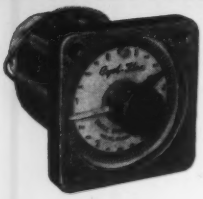
EAGLE

QUALITY BUILT • EASY TO USE

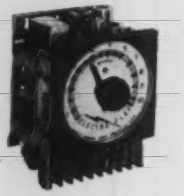
timers and counters



Bulletin 110
20 TURN DIAL RESET TIMER



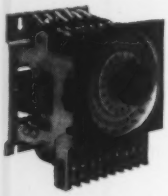
Bulletin 120
SINGLE DIAL RESET TIMER



Bulletin 150
ELECTRONIC RESET TIMER

Bulletin 170
TIME DELAY RELAY

Bulletin 320
ADJUSTABLE REPEAT CYCLE TIMER



Bulletin 720
AUTOMATIC RESET COUNTER

Now in stock for immediate delivery

To better serve your needs without delay, EAGLE now makes available the above Timers and Counters for immediate delivery direct from stocks of EAGLE Representatives in principal cities from coast to coast. See your local phone directory for name and location of your nearest EAGLE Representative. He will be happy to make recommendations and help you engineer your TIME-COUNT problems.

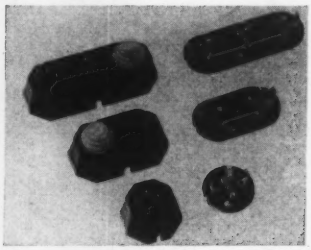
Write EAGLE SIGNAL COMPANY, Dept. MD-859, Moline, Illinois, for descriptive Catalog 351 showing EAGLE'S line of popular TIME-COUNT Controls.

EAGLE SIGNAL COMPANY

A DIVISION OF THE GAMEWELL COMPANY

MOLINE, ILLINOIS

MANUFACTURERS OF THE MOST COMPLETE LINE OF INDUSTRIAL TIME-COUNT CONTROLS



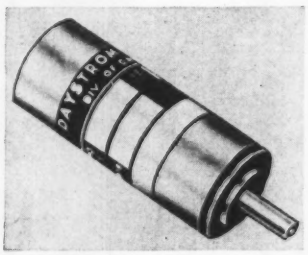
switchboard visual signals as well. Available in one, two, or three-lamp units, they can be used with or without concealed wiring. Lamps are holed for fixed mounting by means of wood screws, or surface placed. Bright-colored, break-resistant, plastic beehive lenses are used. They can be changed easily since provision is made for screw-set lens changing. **Suttle Equipment Corp.**, 135 S. LaSalle St., Chicago 3, Ill. I

Circle 678 on Page 19

Damping Generator

delivers stall torque of 0.11 oz-in. minimum

Size 6 damping motor generator, which weighs only 1.3 oz, delivers minimum stall torque of 0.11 oz-in. Acceleration from stall is 23,600 rad per sec per sec, and moment of



inertia is 0.33 gm-cm². Generator requires input of 1.25 w, 26 v at 400 cps. **Daystrom Transicoil**, Worcester, Montgomery County, Pa. E

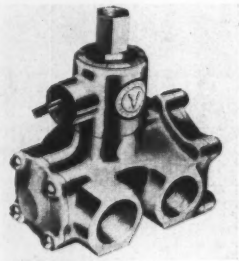
Circle 679 on Page 19

Solenoid Valves

are high-flow, three-way types

Series LC solenoid valves control common media such as oil, air, water, vegetable and petroleum oils, inert gases, kerosine, and gasoline. The high-flow, three-way units are compact, light, mount in any posi-

tion directly to the line, and operate on a pressure differential of 5 to 150 psi. Valves are furnished in ⅜, ½, and ¾-in. full effective orifice sizes. They are available normally open, normally closed, and with directional control, in standard



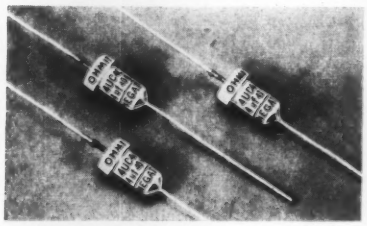
and explosionproof construction. Wide range of voltages and frequencies with many electrical options is offered. Dept. LL134, **Skinner Electric Valve Div., Skinner Chuck Co.**, 105 Edgewood Ave., New Britain, Conn. B

Circle 680 on Page 19

Electrolytic Capacitor

for operation at temperatures to 125 C

Tantalum slug electrolytic capacitor, designated Style UC, has low power factor and leakage current, excellent temperature coefficient, and small size. Capacitor is rated for operation at ambient temperatures to 125 C. Unit exceeds maximum



vibration requirements of MIL-C-3965B and 50-g shock test in accordance with MIL-Std. 202A, Method 205. **Ohmite Mfg. Co.**, 3638 Howard St., Skokie, Ill. J

Circle 681 on Page 19

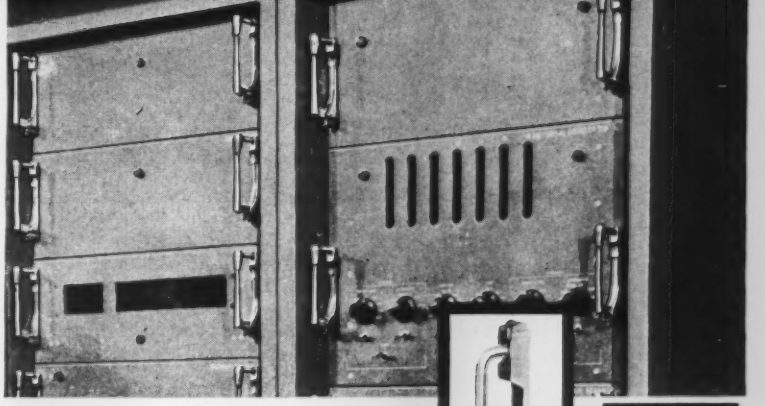
Time-Delay Relay

for dc operation

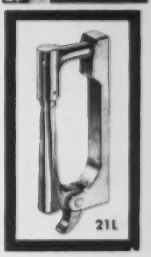
Pneumatic time-delay relay measures only 2-15/16 by 4-27/32 in. Designed for dc operation, it is rated for pilot-duty applications to

DATICO "digital automatic tape intelligence check out" is made by the Nortronics Div. of Northrop Corporation for the U. S. Air Force and U. S. Army Rocket & Guided Missile Agency. This money and man saving tool provides rapid weapon system evaluation. Note Camloc Chassis Latches.

IT'S EASY to
open ■ close ■ carry ■
connect & disconnect
plug-in chassis



with CAMLOC®



multi-function
CHASSIS LATCHES

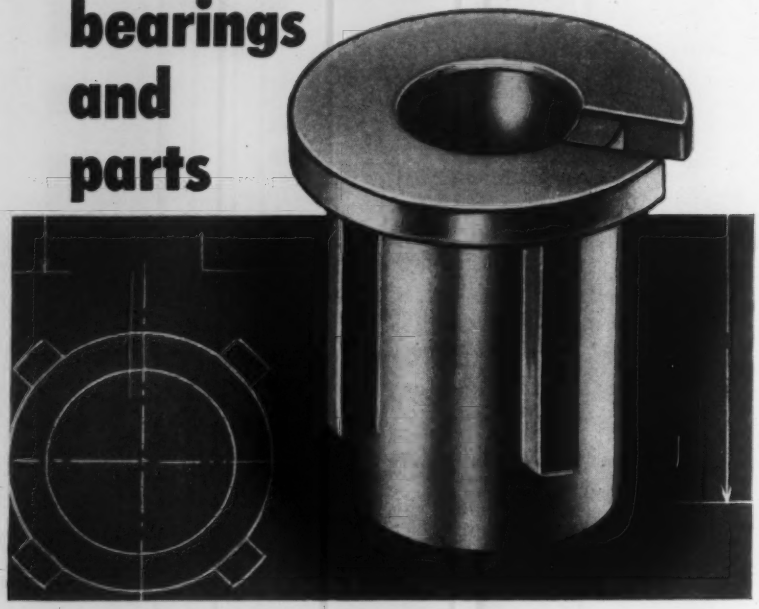
Thirty-eight strong, simple, attractive Camloc multi-function Chassis Latches are used on the 24 equipment filled plug-in chassis that make up DATICO, the military's new universal automatic field service checkout system. Here is a perfect example of designed-in fastener serviceability, flexibility, ease of handling and economy in interconnected "black-box" systems. When the Camloc push-button handles are released and pulled down, the chassis is automatically disconnected and ejected. Then the latch becomes a carrying handle. When replacing the equipment the latch firmly pulls the chassis back in place, making perfect, automatic reconnection of multiple-pin units. It is quick, safe, reliable, vibration-proof. Camloc Chassis Latches consist of only two parts—a handle and a fork—mounted with standard screws. Several handle and fork designs are currently available, all interchangeable. *Write for Camloc's new Bulletin 35L today.*

"Specialists in Fasteners for Industry"

CAMLOC FASTENER CORP. • 37 SPRING VALLEY RD., PARAMUS, N. J.
WEST COAST OFFICE: 5410 WILSHIRE BLVD., LOS ANGELES, CALIF. • SOUTH WEST OFFICE: 2509 W. BERRY ST., FORT WORTH, TEXAS
See us at the WESCON Show—Booths #1106-1108

Circle 540 on Page 19

Bunting makes the "almost impossible" bearings and parts



The photograph shows a sintered bronze bearing used in an exceedingly popular home laundry drier. It offers several unusual features, some of which you may find useful in designs you are considering as sintered parts. In the first place because the splines on the O.D. of the bearing abut the back of the bearing flange, this is a part which would be almost impossible to produce by machining but can readily be produced by powder metallurgy.

Second, the splines do not extend the full length of the bearing but the density of the splines must be the same as the remainder of the bearing. This requires intricate and unusual tooling and understanding of the problem which is one of the reasons why this manufacturer put his design in the hands of Bunting.

For the unusual, as well as the usual, in bearings, bushings, bars and special parts of cast bronze, sintered metals or Alcoa aluminum, see Bunting first.

BUNTING SALES ENGINEERS in the field and a fully staffed Product Engineering Department are at your command without cost or obligation for research or aiding in specification of bearings or parts made of cast bronze or sintered metals for special or unusual applications.

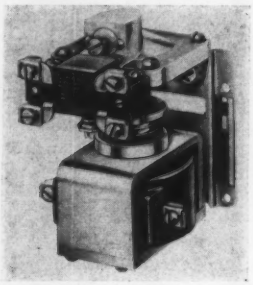
...ask or write for your copy of

Bunting's "Engineering Handbook on Powder Metallurgy" and Catalog No. 58 listing 2227 sizes of completely finished cast bronze and sintered oil-filled bronze bearings available from stock.

The Bunting Brass and Bronze Company
Toledo 1, Ohio EVergreen 2-3451 Branches in Principal Cities

Bunting®

BEARINGS, BUSHINGS, BARS AND SPECIAL PARTS OF CAST BRONZE OR SINTERED METALS. ALCOA® ALUMINUM BARS



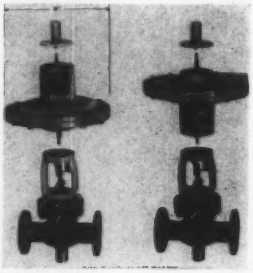
a maximum of 600 v, and provides timing period adjustable from 0.2 sec to 1 min. Type H relay is available for either on or off-delay operation. Invertible magnet structure permits in-the-field conversion from one form of operation to the other. **Square D Co.**, 4041 N. Richards St., Milwaukee 12, Wis. K

Circle 682 on Page 19

Control Valve

has only one operator

Air can be utilized either to open or close valve when single operator of Bantam 540 control valve is inverted. Unit incorporates Teflon packing and gaskets, and has standard body-pressure rating of 300 psi. Body temperature rating is 450 F with standard bonnet, and operator temperature rating is 180 F maximum. Flow coefficient ranges from 0.002 to 13.2. Operator is cast aluminum and utilizes a 3 to 15-psi air signal on a molded diaphragm. It has low hysteresis and linear response. **George W. Dahl Co. Inc.**, 86 Tupelo St., Bristol, R. I. B



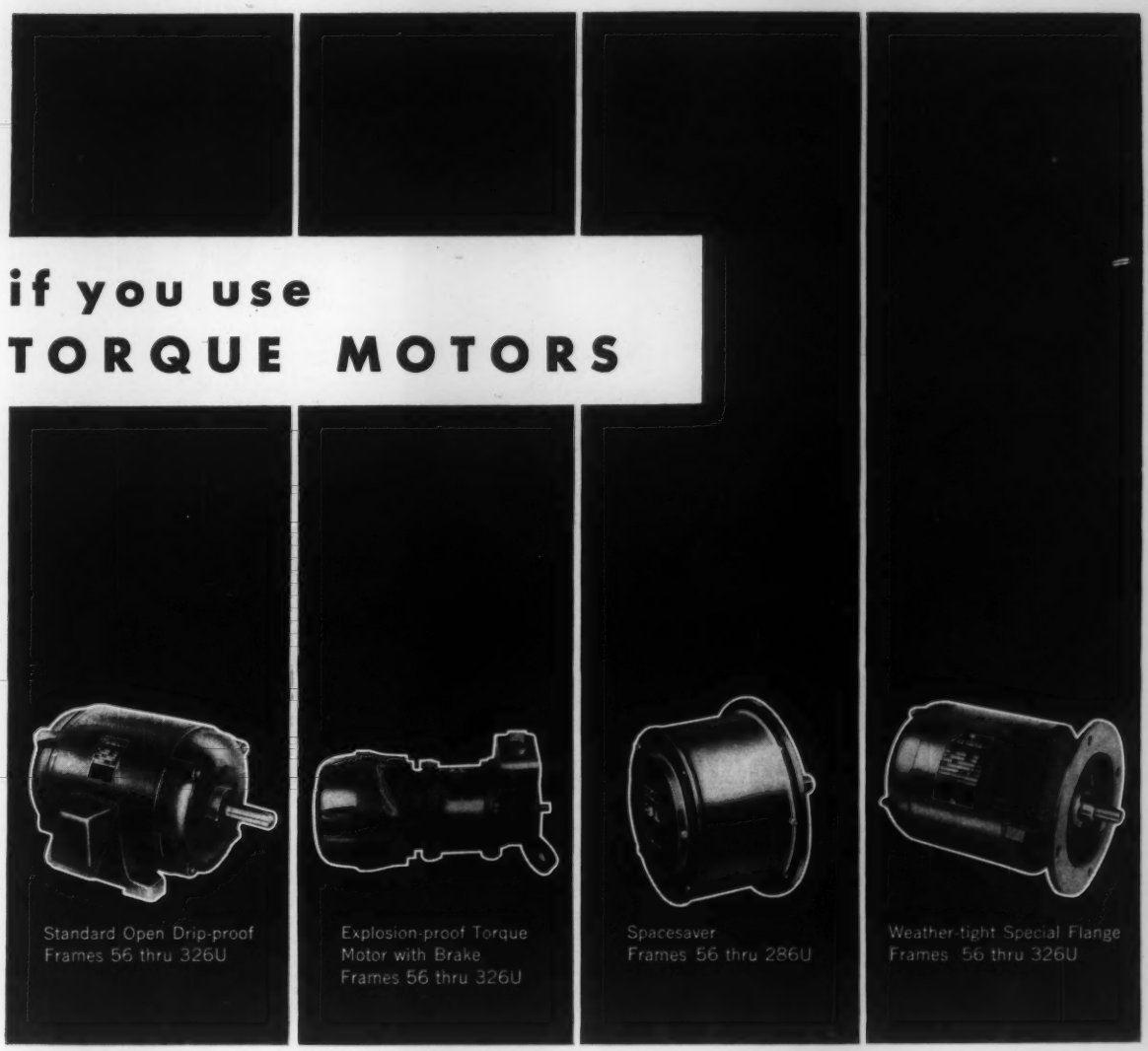
Circle 683 on Page 19

Control Switch

operates in 0.001 sec

Solid-state automatic control switch weighs 9 oz and contains no moving parts. Unit is capable of regu-

if you use TORQUE MOTORS



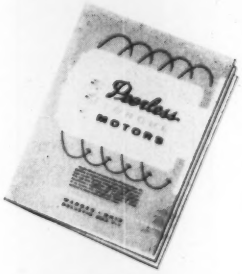
Standard Open Drip-proof
Frames 56 thru 326U

Explosion-proof Torque
Motor with Brake
Frames 56 thru 326U

Spacesaver
Frames 56 thru 286U

Weather-tight Special Flange
Frames 56 thru 326U

RATINGS FROM 2 OZ. IN. to 200 LB. FT.



NEW TORQUE BULLETIN
This bulletin outlines basic facts about Peerless torque motors and shows applications. It is available FREE. Write for it today.

These Peerless torque motors deliver maximum rated torque without damage to the windings when stalled across the line at full voltage for predetermined periods. Peerless also builds torque motors which provide a nearly constant torque while operating at less than synchronous speeds.

All standard frame sizes; all types of mountings; high torques; special paint and varnish treatments; and Class A, B, F, and H insulation are available at Peerless. The special attention and close cooperation required on torque motor design and application have made Peerless a leader in the field. Give your torque motor problem to the Peerless engineers. They'll work with you to develop the torque motor that powers your product best.

ELECTRIC MOTOR DIVISION

THE Peerless Electric® COMPANY

FANS · BLOWERS · MOTORS

1520 W. MARKET ST. · WARREN, OHIO

Circle 542 on Page 19

Onan NEWS REPORT

Onan 13 H.P. engine powers 100-mile-an-hour air blast!

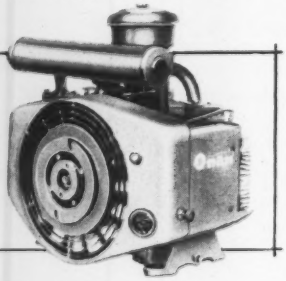
This Model 50 Rotomist, manufactured by the John Bean Division of Food Machinery and Chemical Corporation, is a highly mobile mist sprayer used for pest control, sanitation, and treatment of tree diseases. Powered by a 13 horsepower Onan CCK engine, the Rotomist delivers 12,000 cubic feet of air per minute at a velocity of 100 miles per hour.

The Onan CCK offers unique advantages for this type of mobile application. It is capable of *sustained operation at over 3,000 r.p.m.* Alternate-firing, two-cylinder, opposed design is compact and *free from vibration*. Extra-large bearings and rugged construction make it a dependable, long-life power source.

Give *your* equipment a performance *bonus* with Onan CCK power!

Onan Model CCK-Gasoline or gas-powered

- Over-square design; 3¼-inch bore; 3-inch stroke.
- Rotating Stellite-faced exhaust valves.
- Solid Stellite exhaust valve seats.
- Full pressure lubrication.
- Axial-flow cooling.
- Short, extra-heavy crankshaft.
- 3-quart oil sump.
- High tension magneto ingition.



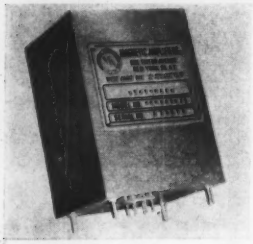
Find Us Fast In The Yellow Pages

Call the Onan distributor listed in your telephone book or write for complete specifications.

D. W. ONAN & SONS INC.

ELECTRIC PLANTS GENERATORS ENGINES ENGINE-COMPRESSORS
3017 University Avenue S.E. • Minneapolis 14, Minnesota

Onan PRODUCTS



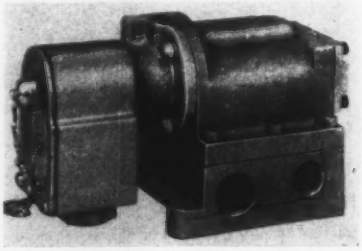
lating complex industrial manufacturing processes at a speed of 0.001 sec. Designated Stat-Pack, it measures 2 x 1¼ x 3 in. and replaces electromechanical relays employed in complex control systems. Device combines power amplification and logic or decision-making functions in one package. **Magnetic Amplifiers Inc.**, 632 Tinton Ave., New York 57, N. Y. D

Circle 684 on Page 19

Air-Control Valves

for 5 to 200 psig service

Two, three, four, and four-way five-port valves of popet type are available for 5 to 200 psig service. They have a variety of solenoid pilots, including JIC types, or have pilot heads for remote operation. Short-stroke, positive-sealing poppets are fully cushioned to prevent impact



damage. Cast-aluminum bodies are available in both in-line and subbase-mounted styles. **Hoffman-Odom Co.**, 2360 W. Dorothy Lane, Dayton 39, Ohio. G

Circle 685 on Page 19

Couplings and Fittings

for joining grooved-end pipe

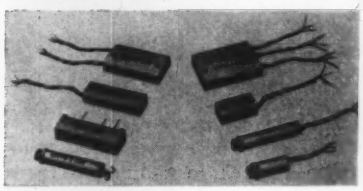
Style 98 Kupl-Lok coupling and fittings for joining grooved-end pipe include couplings, ells, tees, reducers, and line caps. Two series are available for working pressures to 500 and 1000 psi. Both series

are available with gaskets for general service or for oil and gasoline service. Units meet ASTM and military specifications. They are assembled quickly by drawing up two bolts which extend through coupling halves. Gaskets firmly grip pipe ends, maintaining even pressure around circumference of pipe to afford a leakproof, permanent seal. Gaskets also enable piping to absorb pipeline stresses and movements safely. **Dresser Mfg. Div., Dresser Industries**, Bradford, Pa. N

Circle 686 on Page 19

Subminiature Potentiometers

in seven sizes and configurations



Subminiature trimming potentiometers are supplied in seven different sizes and configurations for chassis, panel, or printed-circuit mounting. Termination is accomplished by flexible leads, solder lugs, or printed-circuit pins. Models are available with wirewound, slide wire, and carbon elements, with slide wire and carbon types providing infinite resolution. Instruments operate efficiently under extreme environmental conditions and are available in power ratings to 2.75 w at 50 C. High-temperature models have operating temperature range of −55 to +180 C. Units are interchangeable with other trimming potentiometers and are completely sealed in one-piece, anodized-aluminum or high-temperature plastic case. **Con-Elco**, 1711 S. Mountain Ave., Monrovia, Calif. L

Circle 687 on Page 19

Indicator Tube

operates continuously for over 30,000 hr

Nixie indicator tube, Type B7031, provides a numerical display of digits zero through nine in a common viewing area. Characters are 2 in. high and are visible at distances of over 150 ft. Unit operates continu-

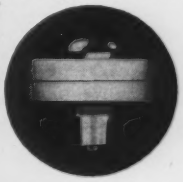
Townsend Lockbolts now available in Stainless Steel for greater strength ...corrosion resistance

If you need extra strength in fastening your assembly—plus corrosion resistance—you can get both now with Townsend 18-8 stainless steel lockbolts.

The use of Townsend stainless lockbolts gives you greater flexibility of design and the values are highly uniform. There is no chance for human error in setting lockbolts. Men with no special training get strong, vibration-proof joints every time.

Townsend stainless lockbolts are vastly easier to install—for example, they eliminate the back breaking work of bucking stainless rivets which work-harden rapidly.

Townsend lockbolts are also available in carbon steel and aluminum alloy in a wide range of diameters and grip lengths in brazier, button and 90° countersunk head styles. Write today for information to Engineered Fasteners Division, P.O. Box 71-E, Ellwood City, Pennsylvania.



Licensed under Huck patents RE 22,792; 2,114,493; 2,527,307; 2,531,048; 2,531,049 and 2,754,703

Townsend Company

Engineered Fasteners Division

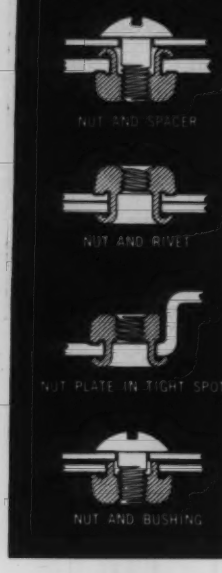
ELLWOOD CITY • PENNSYLVANIA

Circle 544 on Page 19

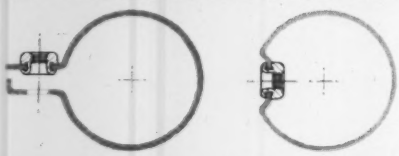
ATTACHMENT AND FASTENING

PROBLEM SOLVER

Perma-Nuts. . . . . applied with standard TRS riveting machines



EXAMPLE: in a pipe clamp and a sleeve attachment



Set in flange of pipe clamp before forming into a circle, Perma-Nut makes a neat, permanent, strong nut plate. Set in dimple to recess clinch, second Perma-Nut makes threaded fitting for attachment screw in two-section tubular handle.

Solve your attachment design problems with PERMA-NUTS. Get the production speed and economy that go with automatic feeding and setting of standard semi-tubular rivets — plus all the fastening flexibility of threaded fittings. A nut plus a rivet, with a built-in "lock washer"! *Write for your free copy of this fact-filled problem-solving catalog.*

TUBULAR RIVET & STUD CO.
Quincy 70, Mass.

Circle 546 on Page 19

HUMAN-FACTORS ENGINEERING

by John D. Vandenberg and C. Thomas Goldsmith

Thirty-one pages of helpful information for the designer contending with human limitations and capabilities. Special emphasis is given to design for vision, hearing, muscular performance and body dimensions in relationship to man-machine efficiency **$1.00 per copy**

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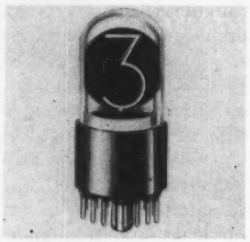


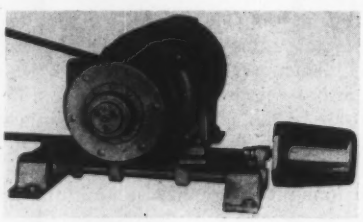
ously without failure for over 30,000 hr. Side viewing design makes possible close stacking of tubes, permitting display of a large amount of information in minimum space. **Electronic Tube Div., Burroughs Corp.**, P.O. Box 1226, Plainfield, N. J. D

Circle 688 on Page 19

Rotary Actuator

for sliding motor base drives

High-torque, rotary actuator provides low-cost remote and automatic control for adjustable-speed drives, valves, pumps, reactors, and machine tools. SM-18 is available with built-in precision potentiometer, gear-connected to output shaft through a wide choice of ratios. From 1/6 to 40 shaft revolutions correspond to full-scale control. Ratings to ¾ hp are available in single and three-phase styles with 500-w units offered in two-phase servo types. Typical unit delivers 200 lb-in. at 50 rpm for remote or



automatic control of sliding-motor base of variable-pitch sheave drives. **Jordan Co.**, 3235 W. Hampton Ave., Milwaukee, Wis. K

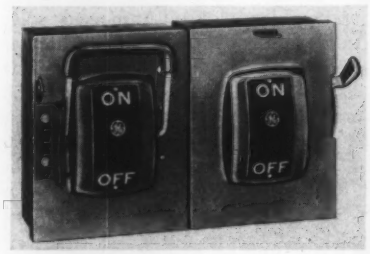
Circle 689 on Page 19

Safety Switches

have no fiber parts in operating mechanism

Light and heavy-duty safety switches have a highly visible, red, insulated, front-operating handle and large metal nameplate to provide

on-off identification from over 100 ft away. All fiber parts are eliminated from operating mechanism, since fiber is subject to deterioration and possible rupture through age, moisture, and heat. Additional safety features include visible blades, wiring gutters free from moving parts or obstructions, and safety phase barrier to protect personnel from accidental line-to-line contact when inspecting a live switch. Ratings for heavy-duty switches, Type TH (left), are 250 and 600 v ac, 30 to 600 amp. Light-duty, Type TG, devices are rated 30 to 600 amp,



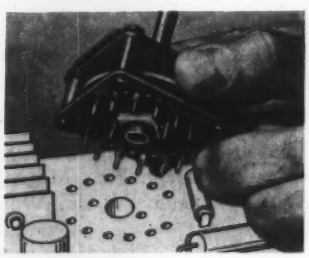
120/240 and 240 v ac. **Circuit Protective Devices Dept., Distribution Unit, General Electric Co.,** Plainville, Conn. B

Circle 690 on Page 19

Rotary Switch

miniature unit mounts in 1/16-in. circuit boards

Miniature precision printed-circuit switch has 0.031-in. diam terminals that mount quickly in printed circuit boards up to 1/16-in. thick. Designed for extremely compact instruments, computers, and other electric-electronic equipment, switch measures only 1¾ in. square and has 1-in. back-of-panel depth for first deck. It is available in both shorting and nonshorting types with one to four poles and up to 32 positions per deck. Use of glass-epoxy switch plates provides high insulation resistance, constant op-



NOW AVAILABLE

STRATOFLEX

FLARED TUBE TYPE ELBOW FITTINGS AND ASSEMBLIES

For confined space installations where hose fittings of minimum dimensions are required

For complete information, write for Bulletin S-4 today.

Installation of hose assemblies in a confined space has long been an industry problem. To solve this problem, Stratoflex has developed a flared tube series of elbow hose fittings and assemblies.

Use of these Stratoflex assemblies eliminates the need for combinations of fittings and elbow adapters.

- Form tubing used for fabrication of fittings to allow uniform flow.
- Fittings available for medium and high pressure applications and for transmission of all fluids.
- All fittings are quality steel, quality controlled in manufacture.

SFS-9

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Circle 547 on Page 19

AVAILABLE FROM LOCAL STOCK

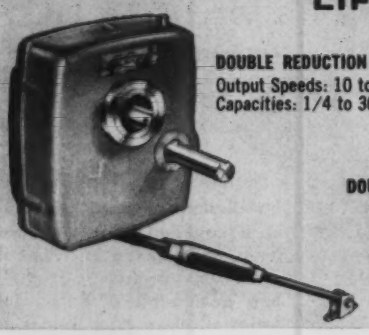
FOOTE BROS. SHAFT MOUNTED DRIVES

WITH

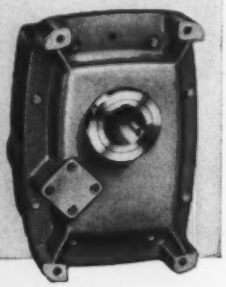
Duti-Rated®

LIFETIME GEARING*

SINGLE REDUCTION
Output Speeds: 90 to 420 RPM
Capacities: 1/4 to 40 HP



DOUBLE REDUCTION
Output Speeds: 10 to 160 RPM
Capacities: 1/4 to 30 HP

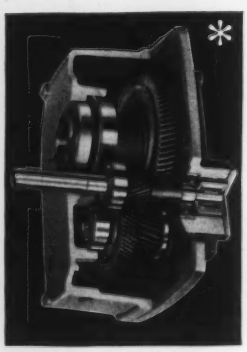


DOUBLE REDUCTION FLANGE MOUNT
Output Speeds: 10 to 135 RPM
Capacities: 1 to 7 HP

Foote Bros. Shaft Mounted Drives offer more efficient, more economical, power transmission. They incorporate exclusive **Duti-Rated** Lifetime Gearing — the high hardness, balanced design, premium quality gearing that combines greater load carrying capacity with long service life.

Used with standard V-Belts and Sheaves, Foote Bros. Shaft Mounted Drives will provide virtually any output speed you may require. Quick, easy installation on driven shafts with diameters from 15/16" to 3-7/16" saves time, labor . . . eliminates need for reducer mounting, couplings, and adjustable motor mount. Built-in Backstop to prevent reverse rotation, Automatic Overload Release Torque Arm, Variable Pulley, are available as optional equipment.

The complete Foote Bros. Shaft Mounted Drive line is made in accordance with all applicable AGMA Standards



Write for NEW SHAFT MOUNTED DRIVE CATALOG

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Better Power Transmission Through Better Gears

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4567 SOUTH WESTERN BOULEVARD • CHICAGO 9, ILLINOIS

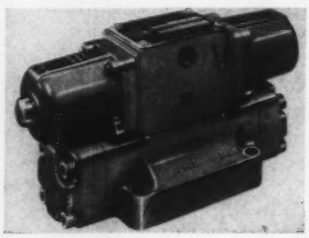
erating temperature of 200 C, high mechanical strength, and low moisture absorption. Variety of optional features, such as adjustable stops, single or cluster-arm rotors, and one or two-way spring-return actions, is available. **Shallcross Mfg. Co.**, Selma, N. C. A

Circle 691 on Page 19

Four-Way Valve

¾-in. unit has oil-immersed solenoids

Four-way, ¾-in. valve for pilot-operated, solenoid-controlled applications features oil-immersed solenoids and is completely interchangeable with industry standards. It is available for pressures to 3000 psi and provides flow of 20 gpm. Solenoid can be removed with valve body for inspection without breaking primary electrical connections. Subplate-mounted valve is provided with optional spools for all standard four-way applications. It has excellent flow characteristics with minimum back pressure. **Hydraulic Press Mfg. Co., Div., Koehring Co.**, Mt. Gilead, Ohio. G



Circle 692 on Page 19

Miniature Capacitors

have 0.22 to 6.8 mfd capacitance range

Case of miniature solid-electrolyte tantalum capacitors, designed to meet applicable military specifications, is 0.125 in. in diam by 0.25 in. long. Electrical leakage is less than 0.01 mu amp per mfd-v for 6 to 20-v units and 0.04 mu amp per mfd-v at 35 v. Capacitance range is 0.22 to 6.8 mfd. Operating temperature range is −80 to 125 C, and dissipation factor is less than 6 per cent. Dept. 823, **Magnavox Co.**, 2131 Bueter Rd., Ft. Wayne, Ind. J

Circle 693 on Page 19

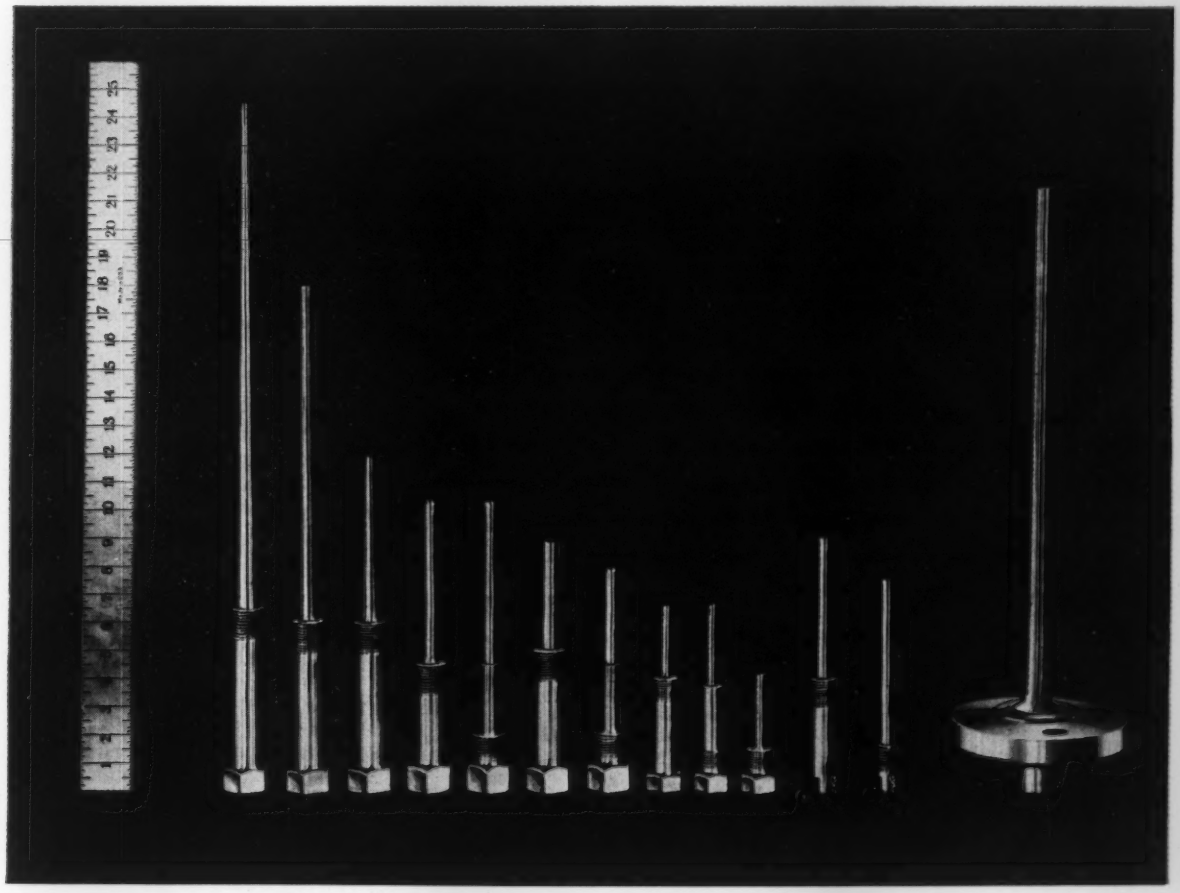
for uniform machinability, strength and oxidation resistance

. . . it had to be Stainless

Drilling blind 3/16" holes down through thermocouple wells up to two feet long can be a heart- (and profit-) breaking job unless the steel is truly uniform. Uniform machining qualities were the fabricator benefits that brought Carpenter Stainless No. 4 (Type 302) and No. 8 (Type 303) into the picture. The benefits that keep Carpenter in the picture are:

(1) increased production (2) lower costs (3) less machining time (4) fewer rejects

all evident immediately after switching to these Carpenter stainless grades. Your local Carpenter Representative may have a suggestion that can bring you the same kinds of benefits on a tough job. The Carpenter Steel Company, Reading, Pa.



a new company 70 years old

Carpenter steel

The Carpenter Steel Company, Main Office and Mills, Reading, Pa.
Alloy Tube Division, Union, N. J.
Webb Wire Division, New Brunswick, N. J.
Carpenter Steel of New England, Inc., Bridgeport, Conn.

Circle 549 on Page 19

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TWO HELPFUL BOOKLETS ON ELECTRIC MOTORS AND POWER SUPPLIES

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A symposium of six articles on the selection, specification and application of—

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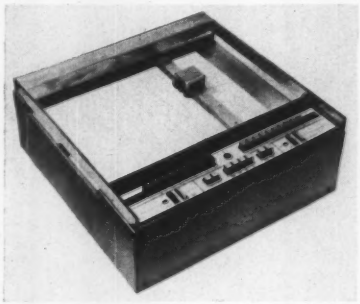
ENGINEERING DEPARTMENT

EQUIPMENT

X-Y Plotter

is pushbutton-operated unit

Model 210 X-Y plotter offers immediate scale switching by pushbutton; vernier control permits scale expansion to next setting. Flat-vacuum platen and provision for precision positioning facilitates paper alignment and loading. Unit features static accuracy of ±0.1 per cent of full scale and dynamic accuracy of ±0.2 per cent of full scale at 10 ips tracing speed. Separate switching circuit for X reference and Y reference permits translation of X and Y origins to any position in plot area. Tracing action of pen is splatterproof and provides legible inking. Plotter can be installed to operate in either horizontal or vertical position. Both control panel and plotting table are available for 19-in. rack mounting as well as



standard table units. Plotter accommodates a full range of accessory equipment. **Librascope Inc.**, 808 Western Ave., Glendale, Calif. L

Circle 694 on Page 19

Drawing Desks

have attached side auxiliary unit

Lankmark high-style drawing desk has walnut-paneled sides with contrasting off-white drawing-work surfaces and satin-chrome trim. Attachment side auxiliary unit, which

AT LAST A CONCLUSIVE NON-DESTRUCTIVE TEST OF PRESSURE TUBING QUALITY

MEETS A.S.T.M. SPECIFICATIONS—Damascope is a new and improved method of RADAC eddy current testing. It consistently reveals surface and sub-surface cracks, seams, splits, holes, inclusions and other discontinuities not revealed by any other inspection method. On production run testing, Damascope's range of sensitivity exceeds requirements for pressure tubing outlined in A.S.T.M. Book of Standards, Part I.

FOR COMPLETE INFORMATION ON DAMASCOPE TESTING
Write for bulletin describing operation, range of sensitivity, advantages, and general background on Damascope testing.

EVERY TUBE IS TESTED—All Damascus pressure tubing is now Damascope inspected in addition to other accepted testing procedures. Damascope is an absolute test of quality, revealing the presence, location and size of harmful flaws. The entire periphery of the tube is examined inside and out, through the wall, and for the full tube length. *This is a 100% check*—each tube is inspected and imperfect tubes are automatically rejected.

SUITABLE FOR NUCLEAR WORK—For nuclear or other critical applications, Damascope can be even more closely calibrated to yield a tube of super quality. Damascope is powered by batteries which eliminate the variable effects caused by current surges. It also employs modulation analysis to separate eddy current signals from background interference.

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STAINLESS STEEL TUBING AND PIPE
GREENVILLE, PENNSYLVANIA

AMERICAN STEEL WAREHOUSE ASS'N

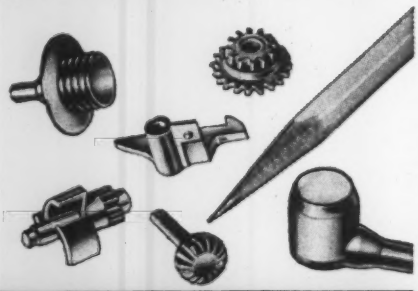
POWDER STEELS INSTITUTE

Circle 551 on Page 19

GRC produces tiny die castings, exclusively! One fast automatic operation turns out simple or intricate parts, high in quality, low in cost

Gries' exclusive patented methods make possible wide design latitude . . . assure uniformity, accuracy and smooth surfaces on small parts of all types . . . for a wide variety of uses . . . at substantial savings. GRC die castings leave the machines trimmed, ready-for-use. In addition GRC's unique single cavity die casting techniques offer new shortcuts in assembly . . new approaches in product design through our exclusive methods.

NO SIZE TOO SMALL!
Maximum sizes
up to 1¾", ½ oz.



tiny die castings exclusively

INTERCAST
Movable, multiple element units "cast-assembled" in one automatic operation.

Automatic **INSERT** casting of individual, multiple or continuous elements or parts.

Perfect **MATING** of any number of zinc alloy or thermoplastic parts.

GEARS and PINIONS
cast in one piece with shafts, center holes, or in combination with cams, hubs, spacers and flanges.

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GRIES

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GRIES REPRODUCER CORP., 32 Second St., New Rochelle, N. Y.

Yes send complete catalog describing GRC automatic Die Casting methods including design hints.

_____Send assorted samples_____quote-info attached
_____Yes _____No. Have representative phone for an appointment.

offers convenient storage and space-saving working area, is a quarter-turn from desk. Three basic components are a front table, basic table, and rear reference desk. Drawing surface is basswood, off-white for pencil-line contrast. Board has anodized aluminum pencil trough and linoleum mounting strip. Ease of assembly or disassembly is achieved by knock-down construction with lock-pin fasteners. **Drafting Equipment Div., Hamilton Mfg. Co.,** Two Rivers, Wis. K

Circle 695 on Page 19

Photocopying Machine

prints 60 to 120 copies per hour

Weighing only 15 lb, portable photocopying machine automatically exposes, processes, and prints 60 to 120 sharp, errorfree copies per hour. New model Porta-Fax reproduces anything printed or written up to 9¼ in. wide by any length. It handles work in colors and ball-point pen, and can be used for duplicate copies from one negative, two-sided copies, color-coded sheets, and transparencies. Completely self-contained, unit measures 18 x 6 x 10 in. high and is equipped with carrying handle. It operates on 115 v ac, and performs efficiently under all normal office and factory light. **General Photo Products Co. Inc.,** General Photo Building, Chatham, N. J. D

Circle 696 on Page 19

Miniature Transducer

for rocket engine test environments

Miniature pressure transducer, P285TC, is oil damped to withstand violent pressure transients generated in shock tubes or transmitted from firing chambers. High natural frequency of undamped miniature flush-diaphragm instruments is retained. Unit is developed for use in rocket engine test environments.

Transducer measures pressures from 0-50 to 0-1000 psi with operational, environmental, and service life advantages of unbonded strain-gage transducers. Case length is 49/64 in. and width between hexagonal sides is 1 in. Output is approximately 28 mv full scale, open circuit at 7 v ac or dc excitation. Nonlinearity and hysteresis are not

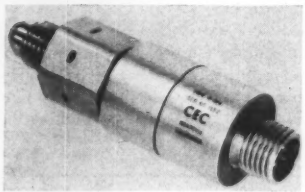
more than ±1 per cent of full scale. **Statham Instruments Inc.**, 12401 W. Olympic Blvd., Los Angeles 64, Calif. L

Circle 697 on Page 19

Pressure Pickup

retains accuracy at 10,000 psi pressure

Chamber-type unbonded strain gage pressure pickup, Type 4-326, has provisions for adjustment of bridge balance, temperature compensation, and sensitivity in a chamber isolated from sensing element. Each pickup can be adjusted to performance specifications of user without affecting precision sensing element inside. Unit retains accuracy at pressures to 10,000 psi absolute or sealed gage. Operable tempera-

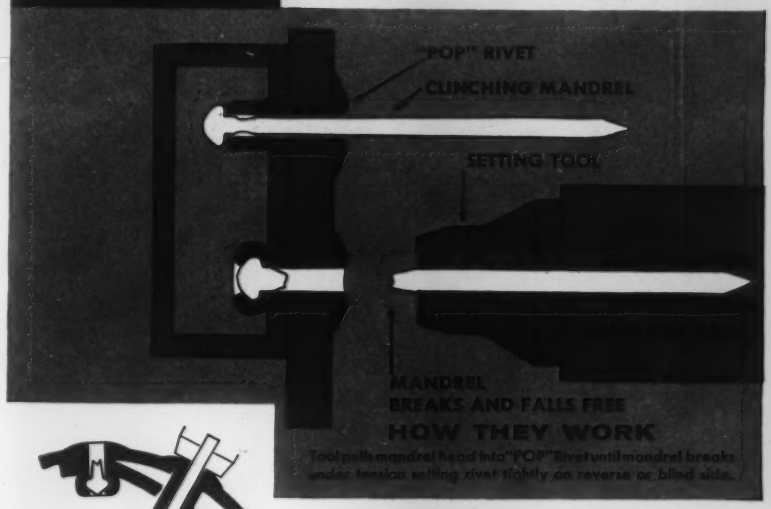


ture range is −320 to +300 F. Instrument is undamaged by severe shock, and shows excellent output characteristics during acceleration, linear vibration, acoustical noise, and varying altitudes. **Consolidated Electrodynamics Corp.**, 360 Sierra Madre Villa, Pasadena, Calif. L

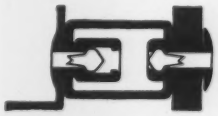
Circle 698 on Page 19

5-Year Study Proves

Each "POP" RIVET Saves 4.9¢ on Installed Costs

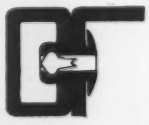

"POP" RIVET
CLINCHING MANDREL
SETTING TOOL
MANDREL BREAKS AND FALLS FREE
HOW THEY WORK
Tool pulls mandrel head into "POP" Rivet until mandrel breaks under tension setting rivet tightly on reverse or blind side.

High Clinching Action
Pulls parts together with up to 600 lbs. squeeze. Eliminates need to clamp.



Wide Grip Range
Simplifies inventory, purchasing, inspection. Same length "POP" Rivet holds tight through thick or thin.

Vibration Proof
"POP" Rivets cannot back out or become loose. Ensures tight assembly for years of use.



Least Back-Up Space
Strong, high strength "POP" Rivets need only enough back-up space to provide room for set head. Gives more compact design.

Saves 4.9¢ each over other blind rivets

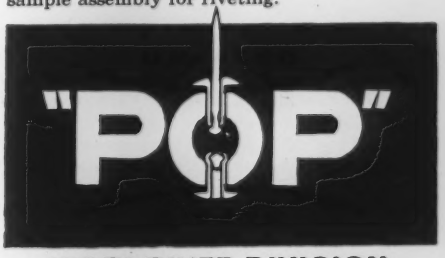
Saves 1.8¢ each over solid rivets

Replace 100,000 solid rivets with strong, high clinch "POP"® Rivets and you save $1,800. Use 100,000 time-tested "POP" Rivets for blind assembly work and you save $4,900.

No other rivet equals the savings potential in *installed costs* provided by "POP" Rivets. The Martin Company saved $223,000 on one fifty-plane contract alone — and with today's rapidly increasing costs, even greater savings are possible. In addition, the extraordinary design flexibility of these rivets gives engineers many opportunities for simplified product design.

Extreme light weight, high production gun — only 2 lb., 3 oz. sharply reduces operator fatigue. Means more rivets set per hour right on the assembly line — rates as high as 1200 per hour even with unskilled operators.

Whether you make planes, missiles, cars, trucks, trailers, metal awnings, furniture, boats, or toys, you can cut costs, simplify design and add assembly convenience with "POP" Rivets. Call or write for our literature now — before you forget. Better still, send a sample assembly for riveting.



"POP" RIVET DIVISION
UNITED SHOE MACHINERY CORPORATION
Shelton, Conn., Regent 5-3391

Circle 553 on Page 19

"Here's a boxful of cost-cutting, product-improving ideas for you"

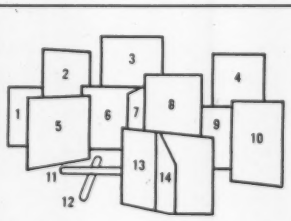
In versatility, performance and cost, Vulcanized Fibre may help crack your next design problem

For proof, look at this National product and its almost unbelievable range of uses. To name a few: delicate surgical instruments; rail joint insulation for railroads; clothes hampers for the home; dense, durable gears and cams; flexible backings for abrasive disks; arc chutes for lightning arrestors; motor insulation; punched tape for data processing machines; formed athletic guard equipment.

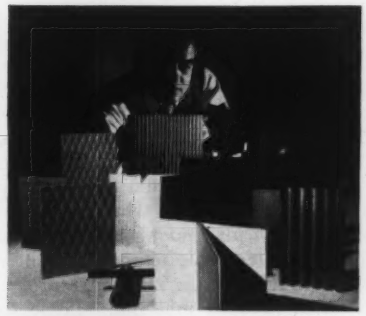
Among engineering materials you'll find National Vulcanized Fibre unique and surprisingly economical. It weighs only half as much as aluminum. It has unsurpassed arc resistance, low thermal conductivity, excellent resilience and high abrasion resistance. It absorbs sudden and repeated shock and impact without failure. And it is available in a fire resistant grade.

After 100 years, users are still finding new things they can do *to* Vulcanized Fibre. It can be machined, polished, painted, embossed, lacquered and combined with other materials, such as laminated plastic, aluminum, wood, rubber, asbestos or copper. It can even be formed or deep drawn into intricate shapes. Available in both standard and special forms and sizes.

Send for our special kit of samples (shown above)—write on your letterhead please—and evaluate the design possibilities personally. Let us know what use you have in mind. We'd like to help. National Vucanized Fibre Co., Dept. G-8, Wilmington 99, Delaware.



1. "Peerless" Electrical Insulation. **2.** Embossed, vinyl finish. **3.** Corrugated "Peerless" .010. **4.** Fibre and "Mylar." **5.** Cold embossed. **6.** Fibre-Copper, two-sides copper. **7.** Black Commercial. **8.** Fibre-Laminated Plastic, two-sides fibre. **9.** Red Commercial. **10.** Corrugated. **11.** Rod. **12.** Tube. **13.** White. **14.** Fibre Armored Plywood.



CHOOSE FROM THESE MATERIALS...

Vulcanized Fibre: 10 standard grades; many special grades.

PHENOLITE® Laminated Plastic: over 80 standard and modified grades; paper, cotton fabric, nylon, asbestos, glass fabric, cotton and glass mat bases; phenolic, melamine, polyester, epoxy or silicone resins.

PEERLESS Electrical Insulation: coil, strip, corrugated.

Extruded Nylon: 2 grades; rod, strip, pressure tubing, special shapes.

Polyester Glass Mat: 4 standard sheet grades; custom molded shapes.

PHENOLITE Copper-Clad Laminates: 10 standard grades.

Combination Materials: Rubber-PHENOLITE; Rubber-Fibre; Wood-Fibre; Metal-Fibre; Asbestos-Fibre; PEERLESS-PHENOLITE.

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Stock Program for Immediate Shipment

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Cleveland ..... ERieview 1-0240
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NATIONAL FIBRE COMPANY OF CANADA, LTD., Toronto 3, Ontario

THE ENGINEER'S Library

Recent Books

Servomechanisms and Regulating System Design, Vol. 1. *By Harold Chestnut and Robert W. Mayer; 680 pages, 6 by 9 in., clothbound; published by John Wiley & Sons Inc., 440 Fourth Ave., New York 16, N. Y.; available from* MACHINE DESIGN, *$11.75 per copy postpaid.*

Adapted to the needs of engineers without previous training in closed-loop control systems, this second edition presents as background material the solution of linear differential equations for both transient and steady-state operation, circuit theory, and system stability. All aspects of a closed-loop control system are described.

New chapters discuss the root-locus approach to analysis and synthesis of feed-back control systems and the use of analog computers to solve control-system problems. Complex plane and attenuation-frequency methods are covered. Design procedure is also extended to multiple-loop systems with multiple inputs.

Scientific Russian. *By George E. Condoyannis; 225 pages, 5 by 6¾ in., ring-bound; published by and available from John Wiley & Sons Inc., 440 Fourth Ave., New York 16, N. Y.; $3.50 per copy.*

Designed to provide a reading knowledge of Russian technical and scientific articles, this book first simplifies learning of the new alphabet. Structure of the language is analyzed from an over-all viewpoint. Then, basic grammatical elements and patterns encountered repeatedly in technical prose are presented. Following details round out the basic patterns so fluency is achieved in reading characters in words, in phrases, and then in sentences.

Elements of Modern Mathematics. *By Kenneth O. May, professor and chairman, Dept. of Mathematics and Astronomy, Carleton College; 607 pages, 6 by 9 in., clothbound; published by Addison-Wesley*

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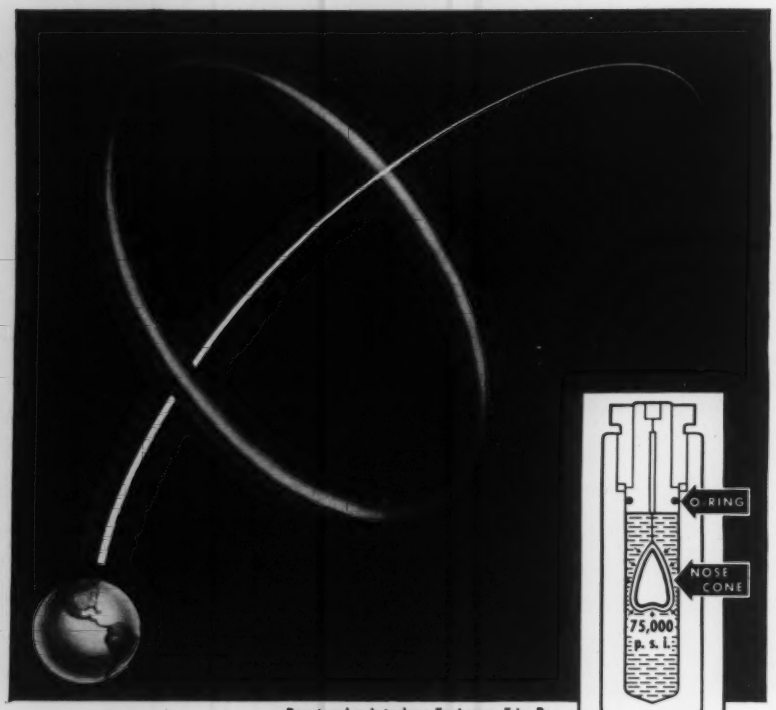
Circle 555 on Page 19



Reactors by Autoclave Engineers, Erie, Pa.

Continental "O" Rings Help Put Satellites in Orbit

Almost as dramatic as the thrust of a satellite into outer space is the technique used to fabricate the nose cone of the missile. These nose cones, made either of powdered metals or refractory materials, are being compacted in 12″ I.D. pressure vessels under hydrostatic pressure of 75,000 P.S.I. *Imagine the problem involved in sealing a vessel against such terrific pressure!*

Yet *THAT* is the problem solved by this Continental "O" Ring. Obviously an ordinary "O" Ring would not do. The job called for a special compound with molecular formation so precise that separation or micro-leakage just could not occur. Continental developed the compound that meets this rigid test. What's more, the elasticity of the rubber refuses permanent set and thus permits re-use of the ring.

This unusual rubber problem typifies the complete engineering service available to you here at Continental. Whether you need molded or extruded rubber parts, consult with us *while your new products are still on the board.* Let us suggest how you might save both tooling and material costs—and get a better product for the job.

Hydrostatic Pressing (see diagram).
A technique for producing uniform compaction and grain structure to obtain super hardness and impact resistance in critical components. A steel forming-mandrel is coated with a refractory material, placed in a rubber bag and suspended in pressure vessel. Pressure is applied until required density is attained.

Engineering catalog.
In addition to custom-made parts, Continental offers an extensive line of standard grommets, bushings, bumpers, rings and extruded shapes. Hundreds of these are shown in the No. 100 Engineering Catalog. Send for a copy or refer to it in Sweet's Catalog for Product Designers.

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Publishing Co. Inc., Reading, Mass.; available from MACHINE DESIGN, *$7.50 per copy postpaid.*

Minimum orientation in modern mathematics, familiarity with terms, and some facility with mathematical concepts and symbols are aims of this textbook. Traditional detail is avoided to permit rapid progress with modern material. Logic and set theory is presented early and used throughout. Simple notation indicates substitution for variables in formulas. In addition to physical sciences and engineering, applications cover the humanities, arts, biology, and social sciences.

Plastic Analysis of Structures. *By Philip G. Hodge Jr., professor of mechanics, Illinois Institute of Technology; 364 pages, 6 by 9 in., clothbound; published by McGraw-Hill Book Co. Inc., 330 West 42nd St., New York 36, N. Y.; available from* MACHINE DESIGN, *$10.50 per copy postpaid.*

Because there are situations where plastic analysis is not appropriate, this textbook explains when, as well as how, to apply plastic methods. Comprehensive treatment of beams, frames, and frame-type structures includes strictly plastic or limit analysis, elastic-plastic deformations, variable and repeated loading, and direct design procedures. Combined stresses in beams, circular plates, and circular cylindrical shells are also covered. Available information permits only a limited discussion of general plate and shell problems and of problems in plane stress.

New Codes

Unfired Pressure Vessels (Section VIII, ASME Boiler and Pressure Vessel Code). *212 pages, 8½ by 11 in., paperbound; available from The American Society of Mechanical Engineers, 29 West 39th St., New York 18, N. Y.; $6.00 per copy.*

All changes made in the Code since the 1956 edition have been incorporated. A major revision concerns a ruling on nodular cast iron. General requirements apply to all unfired pressure vessels designed for pressures not exceeding 3000 psi. Specific requirements deal with fabrication methods such as welding, riveting, forging, and brazing. Classification of materials covers

carbon and low-alloy steels, nonferrous metals, high-alloy steels, cast iron, clad and lined material, and cast nodular iron.

Manufacturers' Publications

RCA Power and Gas Tubes. 31 *pages, 8⅜ by 11 in., paperbound, stapled; available from Commercial Engineering, RCA Electron Tube Division, Harrison, N. J.; $0.30 per copy.*

This booklet contains technical information for RCA power tubes, rectifier tubes, thyratrons, and ignitrons. Over 175 tube types, including 19 new types, are presented. Each tube type is covered by a brief text description; charted dimensions, ratings, and operating values; and a base or terminal-connection diagram. Photographs show representative tube types in each tube family.

Government Publications

Preferred Circuits, Navy Aeronautical Electronic Equipment, Supplement No. 1. *106 pages, 7¾ by 10¼ in., paperbound, side-stapled; available from Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C.; $0.60 per copy.*

Prepared by National Bureau of Standards, this supplement includes circuits for five instrument servos, two regulators, two high-voltage supplies, a pulse a.f.c., and a silicon transistor video amplifier. Characteristics permitting ready selection and construction, explanation of use and design methods, and schematics are provided for each circuit. These circuits were derived after examining numerous examples of both commercial and military electronic equipment.

OTS Technical Report. Available from Office of Technical Services, U. S. Dept. of Commerce, Washington 25, D. C.

PB 151561. Investigation of the Compressive, Bearing, and Shear Creep-Rupture Properties of Aircraft Structural Metals and Joints at Elevated Temperatures. By Luke A. Yerkovich, for WADC; 84 pages, 8¼ by 10¾ in., paperbound, stapled; **$2.00 per copy.**

Two structural alloys, PH15-7 Mo stainless steel and 6 Al-4V titanium, were investigated at 700 to 900 F to establish their creep and rupture characteristics under tension, compression, bearing, and shear stresses. Doubler-type riveted joints incorporating bearing and shear elements were creep tested to correlate joint creep-rupture properties with individually determined bearing and shear creep-rupture properties. Doubler-type joints using C-110M titanium sheet and A-110AT titanium rivets were creep-rupture tested at 800 F to compare actual and predicted joint failure in bearing.

Western Electric

USES

RULON® BUSHING

reduces the number of parts . . . reduces manufacturing costs

Dixon helped Western Electric eliminate a combination of metallic bushings and washers by substituting a tiny RULON* (reinforced Teflon) bushing. The result: some very real assembly and operating advantages.

- **RULON reduces the number of parts:** one bushing replaces bushing/lock washer "combo".
- **RULON reduces manufacturing costs:** wide temperature tolerance (from —450°F. to 550°F) permits bushing to be molded into phenolic body.
- **RULON is self-threading:** adjustment screw that holds tuning slug forms its own thread at final assembly . . . eliminates tapping operation.
- **RULON resists environmental hazards:** vibration, heat, cold, moisture, fungus, chemicals can't affect RULON's performance.

Look at your designs with RULON in mind. If it's a bushing, bearing, cam, wear strip, or insulator, chances are the combination of the correct RULON formulation plus DIXON's manufacturing capabilities can produce the exact component you need. *One of Dixon's many modifications of DuPont TFE Teflon

For engineering data sheet 129-8, write . . .

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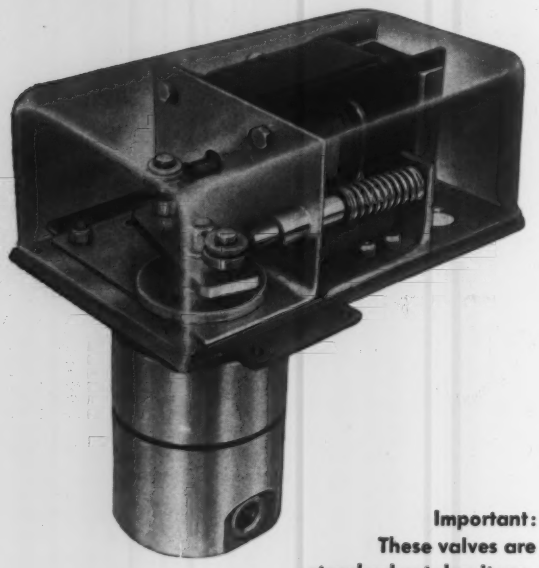
Check these outstanding properties of **RULON**

- Resistance to wear: 500 times Teflon
- Low coefficient of friction: 0.10-0.24
- Wide temperature range: —300° to +500°F
- Excellent electrical properties: Resistivity 10^{15}, dielectric constant 2.6, dissipation factor .002
- Chemically inert — Zero water absorption — Weather resistant
- Low coefficient of expansion: 3.3×10^{-5} (½ that of Teflon)
- Low deformation under load: ½ that of Teflon

Circle 557 on Page 19

10,000 P.S.I. SOLENOID VALVES



Important: These valves are standard catalog items.

● They are available for immediate delivery (in stock) at standard valve prices, for a service which generally requires costly (made-to-order) special valves.

● Shut off and 4-way valves in ¼, ⅜ and ½ inch port sizes are rated for 10,000 P.S.I. liquid or gases. They will withstand surges of up to 15,000 P.S.I. without damage to the valves' sealing qualities (designed for a burst pressure of 30,000 P.S.I.).
Solenoids are available for 115, 230 and 460 volt A.C. operation.

● Long maintenance-free service is achieved through the leak-proof "Shear-Seal" design. Optically flat metal to metal sealing surfaces (of the self-aligning sealing rings and the mating rotor face) are protected by staying in constant intimate contact: flow is always through the center of the "Shear-Seals," never across sealing surfaces. Sealing qualities actually improve as the seals lap themselves to a more perfect fit with each valve operation. There is no external shaft leakage because the pressure is confined to the flow passages.

For complete data write for catalog S-10000.

CONTROL VALVE DIVISION

barksdale valves

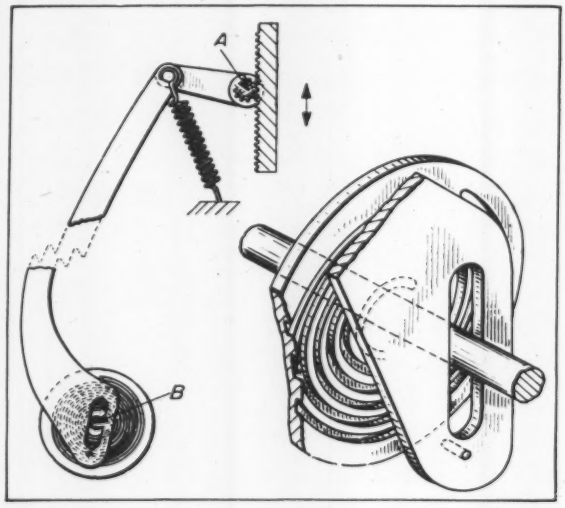
5125 ALCOA AVENUE • LOS ANGELES 58 • CALIFORNIA

NOTEWORTHY

Patents

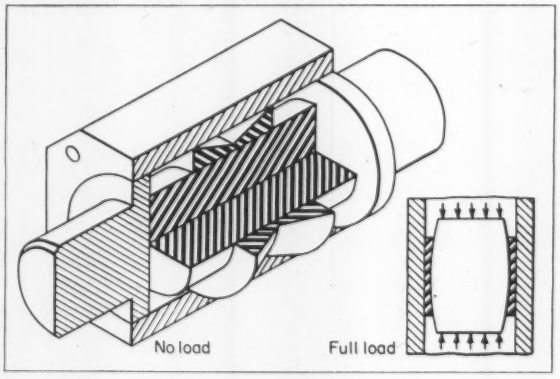
Fine-Adjustment Positioning System

A plate cam and pin-follower system, which provides very fine linear positioning of a rack, supplement coarse adjustment of the same rack by a pinion which rotates on fixed axis *A*. The cam, which is turned about



fixed axis *B*, has a spiral track which receives a pin-follower from a rigid link. As the cam rotates, the link is constrained by a slot to move linearly. A clutch at *A* slips during coarse adjustments, and holds the pinion to its link during fine adjustments. *Patent 2,891,446 assigned to Bausch & Lomb Optical Co., Rochester, N. Y., by Gennaro S. Maiorino.*

Compound Energy Absorber

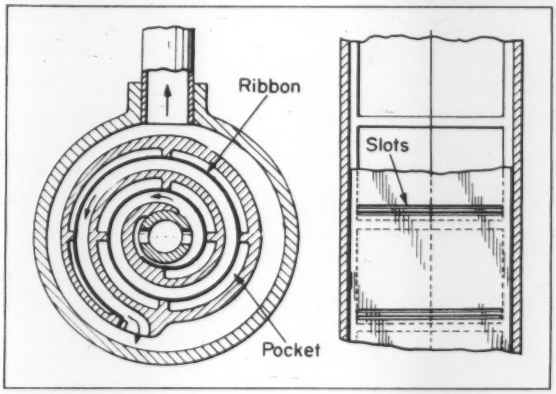


Designed for mounting on a mass which oscillates between two fixed positions in a circular arc, a buffer with two resilient members absorbs two kinds of energy

generated by motion of the mass. Direct compression is absorbed by an axial core member, and a grooved member fitted over the core absorbs energy generated by "hoop tension." The entire system provides uniform stress distribution for the most efficient absorption of energy. *Patent* 2,891,785 *assigned to Westinghouse Electric Corp., Pittsburgh, by Robert M. Sando and Forrest E. England.*

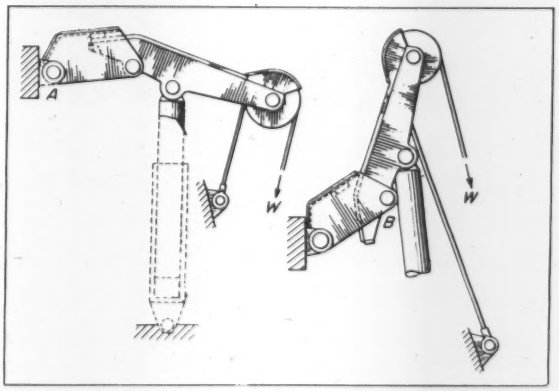
Nonclogging Spiral Filter

In a filter assembly, a spiral-shaped filter core does not reduce fluid flow even though pockets which receive contaminants become completely filled. Raw fluid enters the filter through its center and passes from the



edge of the spiral to the outlet. Centrifugal force from rotation of the filter pumps the fluid and forces contaminants into pockets through slots in a ribbon. This filter is intended for applications in which passage of contaminants through a filled filter would do less damage than complete stoppage of flow for the same reason. *Patent* 2,893,629 *assigned to Michigan Wire Cloth Co., Detroit, by Rex C. Darnell.*

Articulated Lever Mechanism



To lift a load through a relatively short distance, a dual lever assembly provides high mechanical advantage to start the operation, and low mechanical

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saves you up to 40%
ALCOA UTILITUBE
for fuel, air, oil and hydraulic lines

It's a fact! Alcoa® Utilitube actually costs as much as 40% less than copper coiled tube. Made of a specially selected aluminum alloy, 5050-O, it combines low costs with these important benefits:

Outstanding Corrosion Resistance • No Sludge or Gum Formation • High Fatigue Strength • Stands Up Well Under Vibration • Long Lengths (to 1,000 ft) • Light Weight (⅓ that of copper) • Easy Bending with Less Work Hardening

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Get complete design and specification data in the free booklet, *Alcoa Utilitube*. Mail the coupon today!

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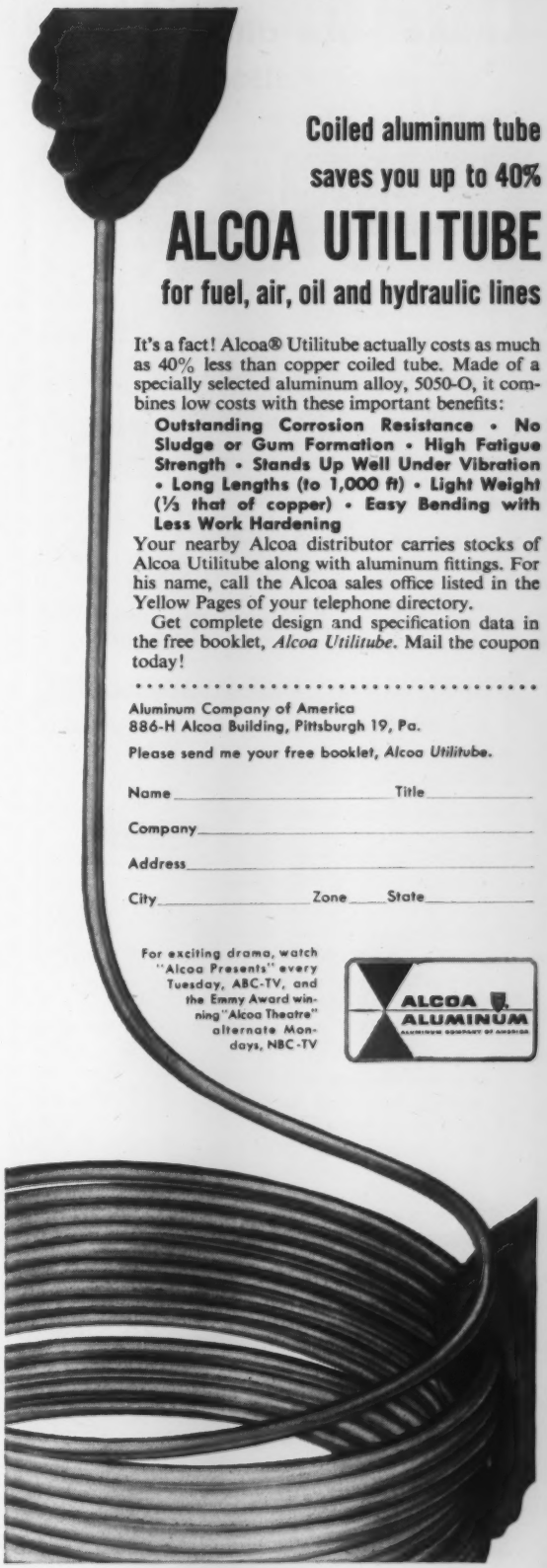
ALCOA ALUMINUM



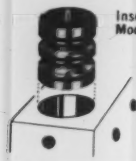
Circle 559 on Page 19

HUMPHREY "Quick-Dump" VALVES

make your difficult applications easy!

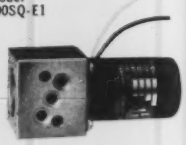
FOR ORIGINAL EQUIPMENT — FOR PLANT USE

3 MOUNTING METHODS



1. EXCLUSIVE INSERT!
Valve inserts into simply machined manifold built to your specs. Manual, piloted or electric actuations. ⅛", ¼" sizes. For pressure or vacuum.

Model 300SQ-E1



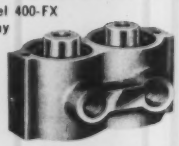
2. "MANIFOLD" PORTING
Square body has all porting on one surface. Minimizes piping, compact for multiple mounting. Man., piloted or elec.* ¼" only

3. STANDARD MOUNTING
Base fits at bottom — or at top (for panel mounting). Also less base for in-line mounting. Sizes ⅛", ¼", ½". 2, 3, 4-way.

3 ACTUATION METHODS

1. MANUAL-MECHANICAL
Palm button, finger-tip key, vertical and horizontal lever, foot pedal and cam-operated actuations to suit your needs.

Model 400-FX 4-way



2. PILOT OPERATED
Actuated by control valve using air or liquid line pressure. Valved medium separated from pilot medium. 2, 3, 4-way. ⅛", ¼", ½"

3. "ELECTRO-PACT"*
Valves have new type electro-magnetic armature. Short travel — long life. No hammering, no heating. Five voltages, AC, DC. Also piloted electrics. 2, 3, 4-way.

Choice of Momentary or Maintained Contact types.

FOR AIR, WATER, OIL, GASES — TO 125 PSI

To help you solve control valve problems, Humphrey offers a wide variety of mounting and actuating choices. Capacities at 100 psi: ⅛" delivers 30 cfm, ¼" 80 cfm, ½" 275 cfm. Our engineers will work with you.

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Humphrey Products
DIVISION OF GENERAL GAS LIGHT COMPANY
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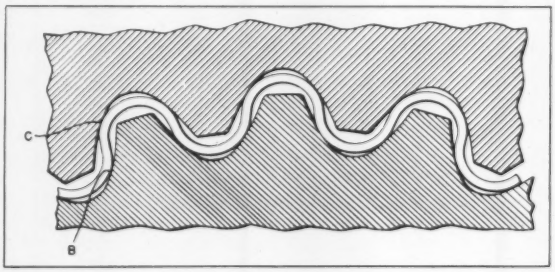
Pneumatic-Hydraulic Valves and Devices
"The Heart of Automation"

advantage at completion. Lifting force comes from a hydraulic cylinder. At the beginning of lift, the fulcrum is pin *A*. Disposition of loads causes the two members of the lever to act as one. Having passed through a certain angle, the smaller lever is stopped by a stationary surface. From that position, pin *B* is the fulcrum. Contact with the load is through a constant length of cable carried by a pulley. *Patent* 2,893,139 *assigned to General Motors Corp., Detroit, by Edward R. Fryer.*

Corrugated Shaft Coupling

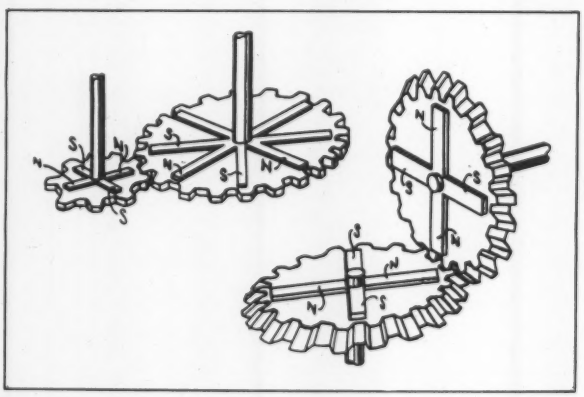
An elastic metal cylinder, corrugated in section, and two gear rings comprise a shaft coupling. In the rings, the teeth have roots in the form of uninterrupted



concave curves. The assembly is designed so that corrugations contact the teeth on the smooth-curve flanks, such as points *B* and *C*. This arrangement minimizes contact stresses in the corrugations. *Patent* 2,893,224 *assigned to The Falk Corp., Milwaukee, by Walter P. Schmitter.*

Magnetic Backlash Eliminator

Permanent magnets fixed to gears in a couple or train substantially reduce or eliminate backlash, depending on the gear ratio and the momentum of moving

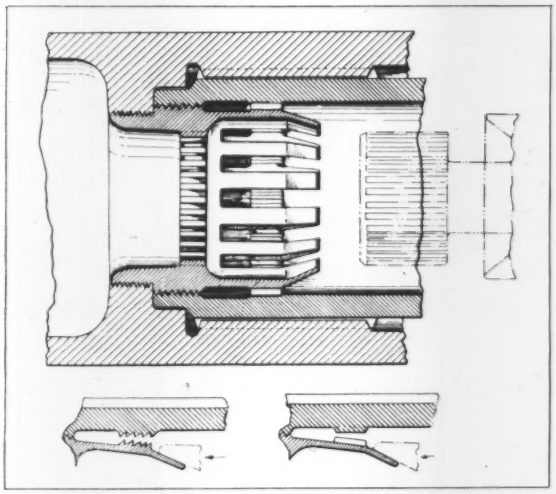


parts. On gears with an even number of teeth, individual teeth can be magnetized, but with the same qualifications. Magnetism causes the gearing to run on only one flank of its teeth. Representative gear ratios are 1:1, 2:1, and 3:1. Where teeth are individually magnetized, a desirable ratio is 10:32. An undesirable

ratio is 41:10. *Patent* 2,893,257 *assigned to Collins Radio Co., Cedar Rapids, Iowa, by Fredrick E. Schulte.*

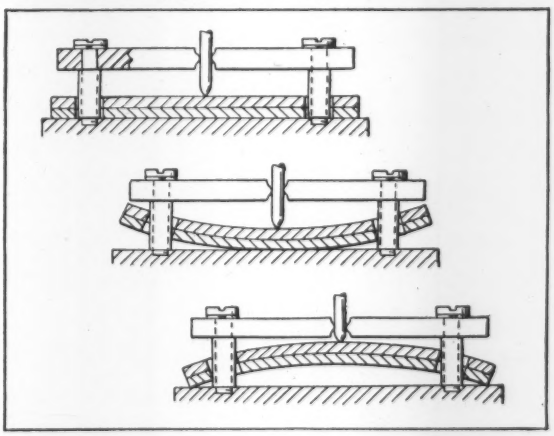
Remotely Operated Pipe Coupling

Two tubes are assembled, one inside the other, by engagement with two lengths of different threads on a coupling inside the smaller tube. The coupling



carries a number of flexible fingers which engage the smaller tube by means of alternate ratchet and spline teeth. To join or separate the tubes, a tool engages a spline in the bushing and cams the fingers inward, out of contact. The tubes can be joined at a remote distance, depending on the length of the tool. *Patent* 2,894,768 *assigned to General Electric Co. by David Robert Davis.*

One-Way Temperature Compensator



A bimetallic, temperature-sensitive member is designed to be flat at a median temperature above which compensation is desired and below which compensation is not desired. The member is freely fitted over two pillars and lies on a flat surface. A shaft, movable

WHICH ENGINE shall you specify?

If you want horsepower, you can't "miss" with this rugged, 56 hp., 4-cyl. V-type VR4D "Wisconsin". Other sizes: 4-cycle single-cylinder, 2-cylinder and V-type 4-cyl., 3 to 37 hp.

While Top Management policy must necessarily dictate the final decision with respect to the original equipment your company manufactures, *design responsibility and recommendations* should be *Engineering* prerogatives and functions. And it is on this basis that Wisconsin Heavy-Duty Air-Cooled Engines merit more than ordinary consideration.

Yes . . . which engine shall you specify? Shall it be an engine that will live up to the most rigid operational service demands of your equipment?

. . . Shall it have behind it engineering experience and talent devoted *exclusively* to the production of heavy-duty engines?

. . . Shall it be backed by a service organization which includes more than 2,000 authorized service stations, ready to service *all* Wisconsin Engine models?

. . . Shall it represent the sum total of more than 50 years of continuous engine progress and development?

. . . Shall it have universal recognition and acceptance by distributors and users of power equipment in the markets of the world?

You can supply the correct answers by specifying "WISCONSIN" . . . dependable engine power to fit the job and the machine. For a briefing on the complete line of Wisconsin Engines, write for Bulletins S-237, S-225, and S-245.

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MILWAUKEE 46, WISCONSIN
World's Largest Builders of Heavy-Duty Air-Cooled Engines
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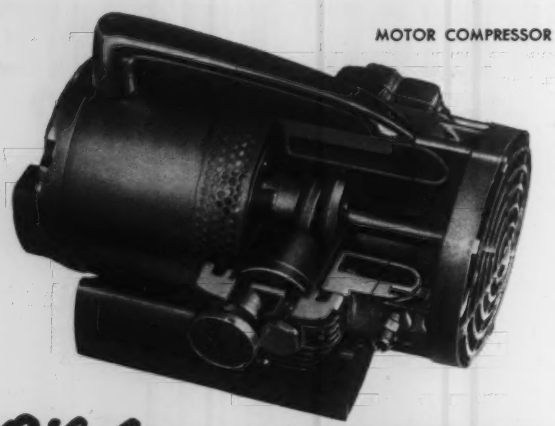
Circle 561 on Page 19

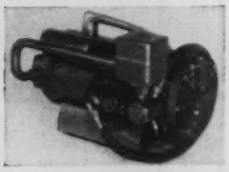
MOTOR COMPRESSOR



Oil-less COMPRESSED AIR

FROM YOUR CHOICE OF 58 MODELS

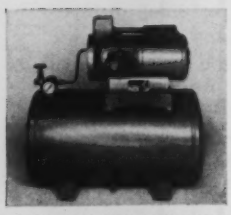
TANKLESS MOTOR COMPRESSORS
For use where existing air tanks or pipe lines provide compressed air storage; 35 and 75 lb. single stage, 175 lb. two stage, ¼ to ¾ HP, 60-cycle motors, displacement to 6.57 CFM at 1725 RPM.



You'll find the compressor you need in the B&G line! Choose from 58 models —lightweight portables, bare compressors, tankless motor compressor outfits, air tank motor compressor outfits; from ¼ to 1½ HP capacities, pressures to 190 psi.

There's never any oil-spoiled work with B&G Compressors—they *never need oiling.* Powered by B&G built motors, they are constructed with carbon graphite piston rings and skirts which need no lubrication; bearings are grease-packed and sealed for life.

Numerous additional design and construction features assure long-lived, dependable delivery of cleaner, cooler, drier air and smooth operation.



10 GAL. AIR TANK MOTOR COMPRESSOR OUTFITS
Available in wide range of capacities; portable when cart-mounted. 35, 75 and 135 lb. outfits mounted on Non-Code Air Storage Tank tested to 150 lbs.; 75 and 175 lb. outfits available with ASME Code built tank tested to 350 lbs.

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Compact, portable 2-gallon tank assembly, easily attached to any B&G 75 lb. or 175 lb. Motor Compressor, or Tankless Outfit.

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75 and 175 lb. outfits mounted on 30 gallon horizontal or vertical air tank built to ASME Code requirements and tested to 400 lbs.

GASOLINE ENGINE-DRIVEN COMPRESSOR OUTFITS
Light weight compact, cart-mounted.

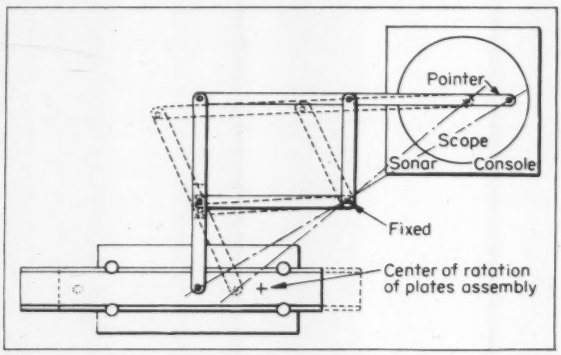
For complete information on B&G Oil-less Compressors and Vacuum Pumps, send for Catalog GO-1156.

Oil-less AIR COMPRESSORS
BELL & GOSSETT COMPANY
Dept. FV-67, Morton Grove, Illinois

axially, contacts the center of the element. Only when the member bows upward does it move the shaft. The same member can be turned over to provide compensation in the opposite sense. *Patent 2,894,392 assigned to Kollsman Instrument Corp., Elmhurst, N. Y., by Robert McLaughlin.*

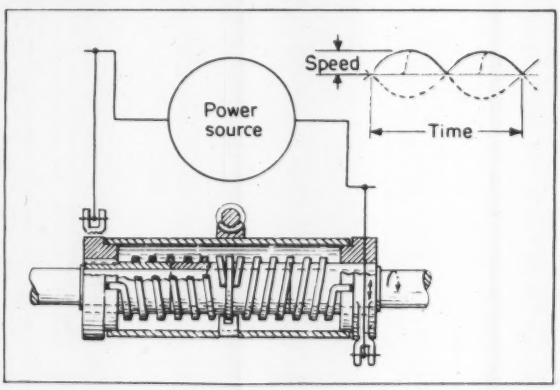
Pantograph Translator of Polar Co-ordinates

Points that occur on a cathode ray tube are tracked manually with a pointer, and converted, through intermediate mechanical assemblies, into radius and angle readings. One intermediate assembly is a pantograph



in which one pivot is fixed. Tracing points and the fixed point of the pantograph are always aligned, thereby assuring a constant displacement ratio. Radial and circular movements of the pointer on the scope cause corresponding motions in the second intermediate mechanical assembly. In turn, the second assembly drives servos which display these motions as quantitative data. *Patent 2,889,627 assigned to the United States of America (Navy) by William B. Culpepper and Jack C. McGaw.*

Adjustable Output Spring Clutch



Without disturbing input, the output angle of a double-spring torque-transmitting clutch can be adjusted from maximum to zero. Input is cyclic, being delivered from cranks and connecting rods attached to opposite ends of two clutch springs. The other spring

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WT. 45 lbs.

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PRESSURE CAPACITY RATINGS

Pressure P.S.I.	Delivery G.P.M.	Motor H.P.
50	1.12	⅓
100	1.08	⅓
150	1.04	⅓
200	1.00	⅓

Using Hydraulic Oil of 170 SSU Viscosity at 100° F Temperature

CYLINDER SELECTION TABLE

Piston Dia. Inch	Cylinder Force Lbs. 50 PSI	100 PSI	150 PSI	200 PSI	Cylinder Speed Inch/Min.
1	39	78	117	157	294
1¼	62	123	184	245	188
1½	88	177	265	353	131
2	157	314	471	628	73

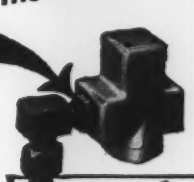
Circle 563 on Page 19

TRU-SEAL

TEFLON SEAL

PAT. PENDING

Saves hours in piping installations



Eliminates leaks in oil, air, water, vacuum, chemical lines

Tru-Seal saves hours in assembling piping installations because it enables you to run your pipe lines in any direction you wish, quickly and easily—without having to recut and re-thread piping sections. Wherever used on air, oil, water, steam, vacuum or chemical lines, it seals perfectly at —100° F. to plus 500° F.—*without the use of pipe dope.* Its installation requires only light tightening torque, thus eliminating over-tightening damage to valves, pumps, compressors, and other fittings.

For further information write

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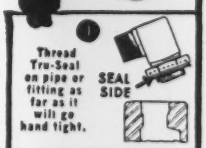
"Miller Fluid Power" is also a Div. of Flick-Reedy Corp.


1
Thread Tru-Seal on pipe or fitting as far as it will go hand tight.
SEAL SIDE
2
Thread pipe or fitting 3 threads into port. Point in desired direction.
3
Tighten Tru-Seal to complete leakproof assembly (only light torque required).

Circle 564 on Page 19

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to your "specs"

National Lock Company sales engineers will work with you in solving all your fastener problems. Our extensive engineering and production facilities are geared to handle your requirements for special-purpose or standard fasteners of uniform quality . . . delivered on time.

Write us.

"KEPS"® REGISTERED TRADEMARK OF ILLINOIS TOOL WORKS

NATIONAL LOCK COMPANY
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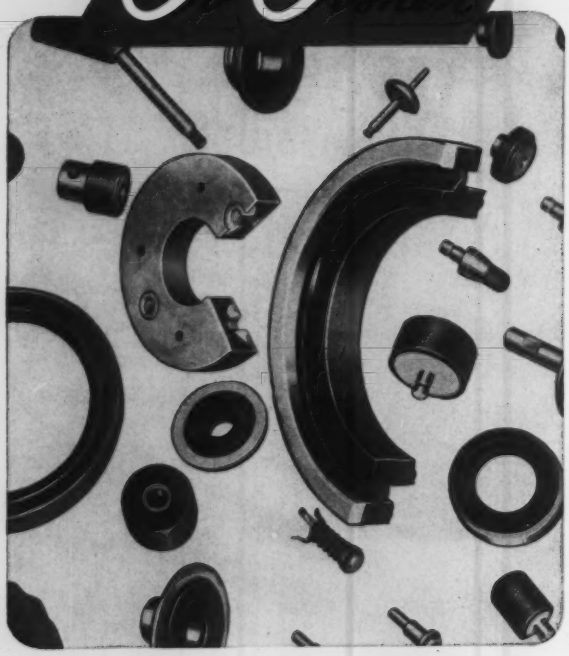
Circle 565 on Page 19

RUBBER
BONDED TO METAL

G Goshen



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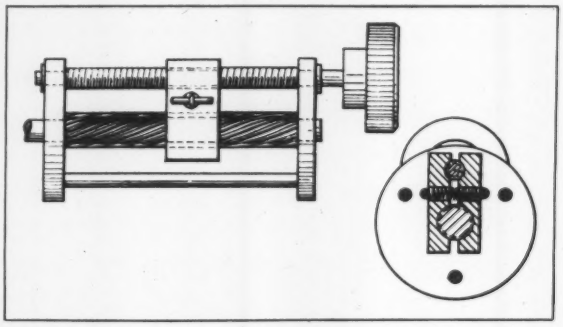
Goshen Rubber Co. Inc.
1789 S. TENTH ST. GOSHEN, INDIANA

ends are fixed to a partition in a cylinder. In turn, the cylinder is positioned radially by an external worm. At maximum output position, the worm adjustment simply prevents overrunning. *Patent* 2,894,403 *assigned to Curtiss-Wright Corp., New York, by Donald R. Tomko.*

Threaded Shaft Speed Reducer

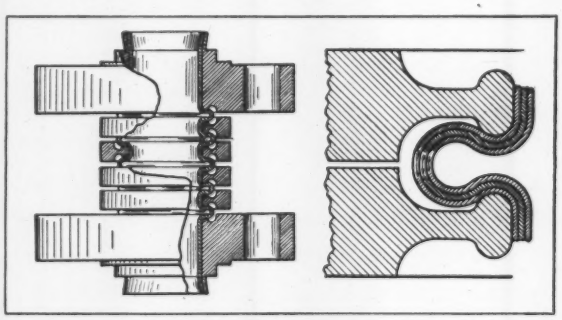
Two parallel shafts and a traveling nut which joins them comprise a speed reducer having fixed limits of



operation. The input shaft carries fine threads; the output shaft, coarse threads. Output rotation is a fraction of input rotation, depending on the ratio of thread pitches. *Patent* 2,894,408 *assigned to North American Philips Co., New York, by Jacob Verhoeff.*

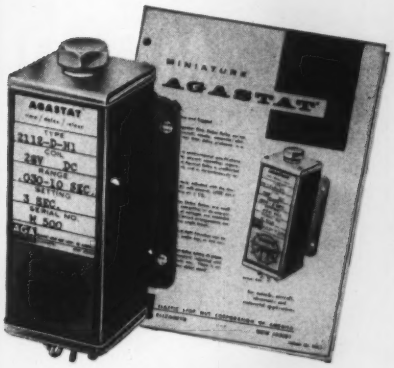
Reinforced Flexible Tubing

Heavily reinforced tubing demonstrates nearly linear expansion and contraction, directly proportional to internal pressure as high as 40,000 psi. The linear



characteristic prevents stress concentrations. Strength members of the tubing are rigid rings fluted about their ID. The flexible member is three-layer, laminated, metal tubing. Convolutions of the flexible tube are carried in toroidal recesses formed by adjacent faces of the rigid rings. *Patent* 2,893,431 *assigned to the Foxboro Co., Foxboro, Mass., by Hoel L. Bowditch.*

Copies of patents briefed in this department may be obtained for 25 cents each from the Commissioner of Patents, Washington 25, D. C.



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Elizabeth, New Jersey

Circle 567 on Page 19

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DISC BRAKES
for hazardous locations

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NEW Max. Torque Ranges — 1½ to 75 lb ft — 17 Sizes

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- BHEW furnishes hydraulic cylinders with single or dual P.O.C. valves, with or without speed control.

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Complete Facilities for Molding by

INJECTION
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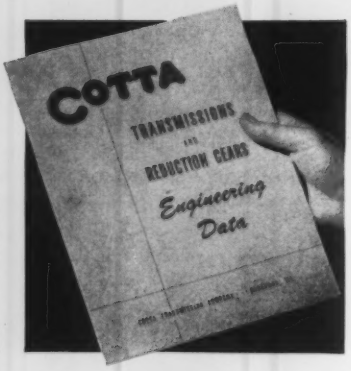

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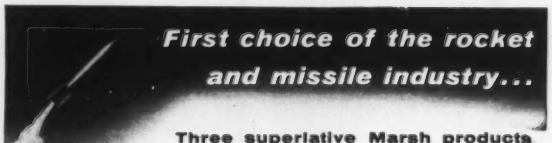

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because they combine the most advanced features ever found in pressure, vacuum and compound gauges. There is a Marsh Gauge for every conceivable application.

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Circle 571 on Page 19

Circle 572 on Page 19

Smooth Sealing

The Rotary Union* is practically effortless in action . . . the smoothest and longest lasting seal ever made. Ball bearings cut friction. The ROTARY UNION automatically compensates for misalignment of worn threads on machine adaptors and avoids strain on sealing surfaces. It automatically adjusts to variations in fluid pressure and maintains its tight mechanical seal when the joint is not in operation.

The ROTARY UNION is available in over 40 standard types and sizes . . . single inlet or syphon type . . . pipe sizes 1/4" through 3". Write for Bulletin 700A.

*Trade Name - Patented

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Circle 573 on Page 19

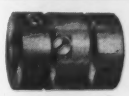
Newest MINIATURE FLEXIBLE COUPLING

Life Saver size - only 7/16"x 3/4"

Renbrandt offers a complete line of ultra-compact, precision-made couplings featuring *zero backlash, low inertia and high flexibility*.

Typical is the newest shown above which is Life Saver size. Specifications: bores in any diameter from $\frac{1}{16}$" through $\frac{3}{8}$", compensates for misalignments of ±5° angular and ±.015" linear, torque 30 inch ounces, weight .19 ounce, moment of inertia as low as .006 ounce inches², materials and finishes to applicable government or MIL specs.

Long-life Renbrandt Couplings will solve many problems where space and weight are at a premium. Others available in a wide variety of sizes for $\frac{1}{8}$" through $\frac{1}{2}$" shafts.



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Low cost for general application. Thousands of uses. ½" dia. x 1½" long. For ¼" and/or $\frac{3}{16}$"-shafts. No backlash. Insulating nylon center piece.

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Circle 574 on Page 19

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Compression diaphragms	Regulator diaphragms
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Fuel pump diaphragms	Vacuum pump diaphragms
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Circle 575 on Page 19

Circle Clamp

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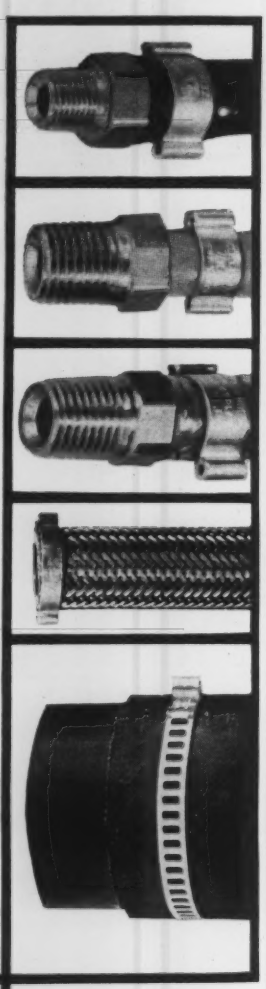
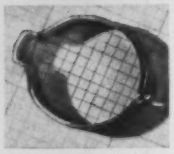
LOW IN COST

EASY TO APPLY AND REMOVE

Adapts Easily to Mass Production Applications.





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- Large bearing surface
- Permits variation in hose O.D.
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Circle Clamps provide holding action equal to or better than any hose clamp available today. Write for complete descriptive information, stock sizes, prices and engineering aid.

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Cuyahoga Products Corporation

A subsidiary of RIC REPUBLIC INDUSTRIAL CORPORATION

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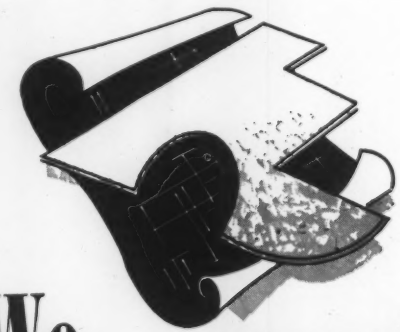
Circle 577 on Page 19



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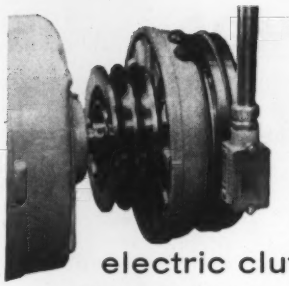

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WARNER **Warner Electric Brake & Clutch Co.**
Beloit, Wisconsin

Circle 579 on Page 19

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746 N. Plankington Ave., Milwaukee, Wis.
SPRING REEL HEADQUARTERS FOR ALL INDUSTRY

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better things in smaller packages

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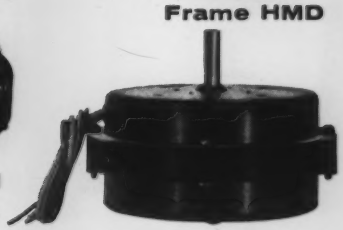
Frame HM



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SPEED: 1800 RPM (variable with frequency)
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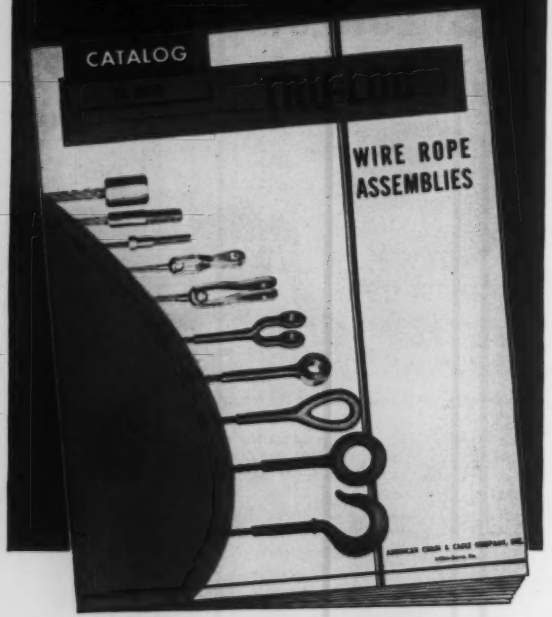
Tru-Loc Wire Rope Assemblies



Standard Tru-Loc Assemblies provide compact, efficient connections at less cost!

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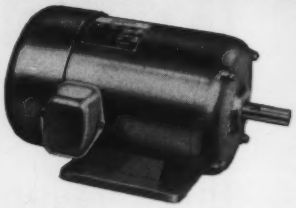

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Circle 583 on Page 19

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Leader in fabrication of silicone rubber products.

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Circle 584 on Page 19

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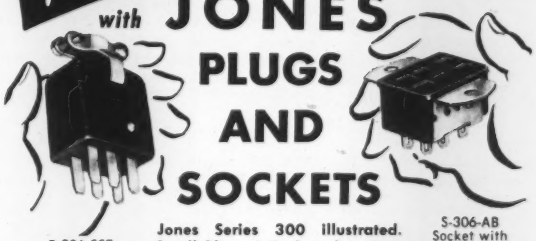

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Circle 585 on Page 19

Concentration on design and production of quality ball bearings for all kinds of uses over a 50-year period has taught us a lot. Like how to move fast when sudden new engineering needs arise. How to keep production flexible when everybody wants everything right now. How much worth there is—to our customers and to us—in pride of workmanship and real understanding of a supplier's duty to meet "when-promised" delivery dates. If things like this make sense to you, talk to us about your ball bearing requirements, whatever they may be. Bearings Company of America Division, Federal-Mogul-Bower Bearings, Inc., Lancaster, Pa.

BCA
BALL BEARINGS

BEARINGS COMPANY OF AMERICA

Circle 586 on Page 19

ENGINEERS
AVAILABLE OR WANTED

WANTED: Opportunities in machine design, engineering mechanics, heat transfer, process engineering, and mathematics—see advertisement page 256 by Continental Can Company.

WANTED: Mechanical Engineers, B.S. and M.S. for research work on mechanical engineering problems related to the steel industry. Salary commensurate with training and experience. Large Research Laboratory, Pittsburgh Area. Forward complete resume and salary requirements to Box 950, MACHINE DESIGN, Penton Bldg., Cleveland 13, Ohio.

WANTED: Development and design engineer. Will consider men up to 50 years of age; graduate M.E. or equivalent, with broad industrial background and with imagination and ability to developing mechanisms; to train as rapidly as possible in the material handling field, to head up a research and development department for the redesign and improvement of product and the development of new items for manufacture. Some board work, some traveling, close association with both shop and management. A fine opportunity if you qualify. Nationally known growth company, Northern Ohio location. Salary commensurate with ability. Pension plan and fringe benefits. Give full resume and tell us how we may contact you for interview. Address Box 949, MACHINE DESIGN, Penton Bldg., Cleveland 13, Ohio.

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COMPANY_____

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Wanted: Engineers

with an interest in writing

Like to break into an interesting field where you'll make good use of your engineering talents — yet have a chance to develop new skills?

We're looking for several men with engineering experience and a yearning to write or edit. As an editor on MACHINE DESIGN, you would broaden your engineering background in a job that provides stimulating contact with people in many engineering areas.

You don't have to have actual writing or editing job experience, although we expect definite ability in handling the English language. An ME or EE degree plus several years of design-engineering experience would be ideal, but we'll be happy to consider equivalent qualifications. Age: 25 to 35.

If you've worked in a design-engineering specialty area, we'd like to hear about it. We're interested in any job experience or training in:

- Mechanical drives, controls, systems
- Mechanical components, assemblies
- Electrical or electronic drives, controls, systems
- Hydraulic or pneumatic systems, drives, controls
- Materials and finishes selection or specification
- Design for manufacture or production design

Our headquarters are in Cleveland. There is opportunity for travel to engineering meetings, expositions, and manufacturing companies. Salary will depend on your background and experience.

If you are interested, send a resume of your engineering background, and any evidence you may have of writing ability (we'll return this if you wish) to: Editor, MACHINE DESIGN, Penton Bldg., Cleveland 13, Ohio.

MACHINE DESIGN

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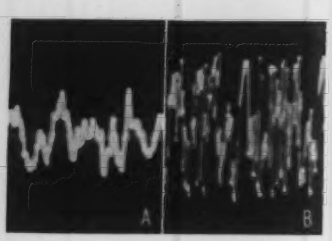
BPA NBP

backtalk——

——Motion Pictures

Every red-blooded engineer has undoubtedly noticed the interesting difference in walking styles of the two main types of people. A few more analytical observers may have even gone so far as to plot motions of representative samples. Data useful of this science have been supplied by the U. S. Army in the form of radar pictures taken with a new ultrasensitive surveillance unit that can spot moving vehicles or people miles away. The two samples here



show *A*, a man walking; *B*, a girl walking. One of our editors, who has been doing this type of motion study for years, commented that he could have predicted *B* wouldn't show up as a simple harmonic curve, but he had no idea . . .

——We See Ourselves

In his studies, Richard W. Wallen, Cleveland psychologist and MACHINE DESIGN author, has observed that in most cases the personality of an engineer is about as different from that of an English professor as it can be. This may strike you as a choice bit of irrelevance; you may even mutter, "So who wants to be like an English professor?" True, there are not many niches that must be filled by a person of such opposite-pole characteristics, but one in this area is very important—an engineering editor. Qualifications of a MACHINE DESIGN editor, outlined in our help-wanted ad on Page 260, are fairly rigid where engineering is concerned, a bit more lenient in the English-prof department. Dr. Wallen's research almost suggests that if there is an animal possessing both characteristics, he would be classed as a "queer duck." Our modifications permit us a more complimentary regard of ourselves—and those who may join our aerie—as rare birds.

——How's That Again?

Dick Templeton, our research and circulation manager, also has to do with the more complex requests addressed to Reader's Service. He recently sent us a copy of a letter which struck him as typical of some reader's service inquiries, with the thought that we in the editorial department probably have seen similar requests. The letter reads:

> "Last year you printed something that interested me very much, but I have forgotten what it was. I lost my notes on the subject and cannot find the magazine. Will you please send me another copy of same?"

This, of course, is ambiguity of such a high order that it precludes fulfillment of the request. We welcome inquiries and can tackle most of them confidently, armed with several elephantine memories and a complete set of indexes. However, the more clues we are furnished, the better.

——This Invention Relates to . . .

Since July 31, 1790, when Samuel Hopkins received the first United States Patent for his discovery of an improvement "in the making of Pot.ash and Pearl.ash by a new apparatus and procefs," the Patent Office has done a land-office business. Volume of patents procefsed in the 169 years since Sam Hopkins is evidenced in the latest copy of the weekly *Official Gazette* of the Patent Office, which shows over 1300 patents granted for the week ending last July 28. Some are particularly intriguing: A separable and reversible snap fastener (for people who insist on wearing their clothes inside-out, maybe), a rinser for one-way bottles (two-way ones shouldn't need much rinsing), a doll with disposable hand and foot members (not as much fun as banging baby brother on the head with blocks, but it has parental approval), and an apparatus for harnessing the power of the wind (what'll they think of next?). It says in Mr. Karger's mighty article on patents (Page 134) that to be patentable, an invention must be useful. It also says that degree of utility required is "not great."

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Technical-ities

By John S. Davey

The strength of nuts

With a hard, heat treated nut, ability to plastically adjust and distribute load over many threads diminishes. High loads tend to concentrate on first thread severely enough to cause stripping . . . or fracture of first thread, which causes locking. Nut then cannot increase tension in bolt.

Untreated nuts are strong enough for most needs, and don't pose this problem.

A CAUSE OF STRIPPING

Upon tightening, a nut both compresses and dilates. Dilation can be overcome by wall thickness only, not by added height or heat treatment.

Dilation is important since a reduction in area of bolt under tension accompanies it. Threads pull away from each other, from their stronger base to weaker tips. The shallowness of *fine* threads can cause progressive shear.

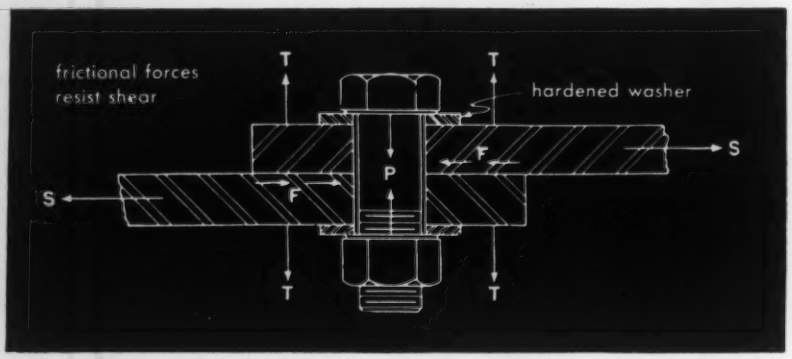
That's why High Nuts (with fine threads) are no answer where "Heavy" Nuts (with coarse threads) are.

WRENCHING STRESS HIGHEST

Rotation of nut produces both tension and torsion in bolt. The force applying this combined stress is about 20% greater than the load which must be sustained when rotation stops.

Thus . . . if a nut hasn't failed in wrenching, it can still withstand at least 20% more direct pull than it sustained during the tightening.

Why high strength bolts make superior joint for dynamic loads



Washers prevent crushing under head and nut with consequent grip relaxation.

While fasteners must be strong enough to carry the calculated loads, what makes a *joint* truly strong is the *residual tension* after wrenching.

NO SLIP OR SEPARATION

Consider the simple lap joint in sketch. Practically rigid, this joint is subjected only to: (1) external tension forces "T" tending to separate the plates against bolt clamping force "P"; (2) shear forces "S" tending to make plates slip against friction resistance "F".

"F" increases when "P" does. With enough clamping force applied, shear loads transfer from one plate to the other without slippage. And when clamping force always exceeds tensile forces, plates obviously *cannot* separate. There can be no further stretch on bolt. Its load stays static at preload "P", even when external loads are dynamic.

UNIFORM CONTROL OF PERFORMANCE

RB&W high strength bolts allow a high magnitude of clamping force to be applied . . . and *uniformly* so. Materials conform to ASTM specifications. Applying known torques to nut produces uniform bolt tensions. Riveting by contrast, depends on difficult-to-control variables.

MORE STRENGTH OVERALL

For shear-resistance, riveted joints offer only the actual rivet shear strength. Don't count too much on friction even though rivets exert some grip as they cool. Compare: a 1-inch bolt tightens to a tension of 42,000 lbs; a 1-inch rivet develops 22,000 lbs at best.

The higher residual tension does more than make a joint much stronger in shear and in tension. It also protects the bolt against fatigue caused by stress-reversing cycles such as vibration; keeps the bolt from loosening, too.

All this explains why, under heavy dynamic loads, rivets can loosen, elongate holes, often fail, requiring difficult replacement; but high strength bolts stand up. They can keep connections permanently tight on vibrating machinery, heavy duty conveyors, and transportation equipment.

Talk it over with an RB&W fastener expert. Russell, Burdsall & Ward Bolt and Nut Company, Port Chester, N. Y.

RB&W high strength bolts are from selected grade of medium carbon steel with proper combination of ductility and tensile strength; conform to ASTM A325.

Plants at: Port Chester, N.Y.; Coraopolis, Pa.; Rock Falls, Ill.; Los Angeles, Calif. Additional sales offices at: Ardmore (Phila.), Pa.; Pittsburgh; Detroit; Chicago; Dallas; San Francisco.

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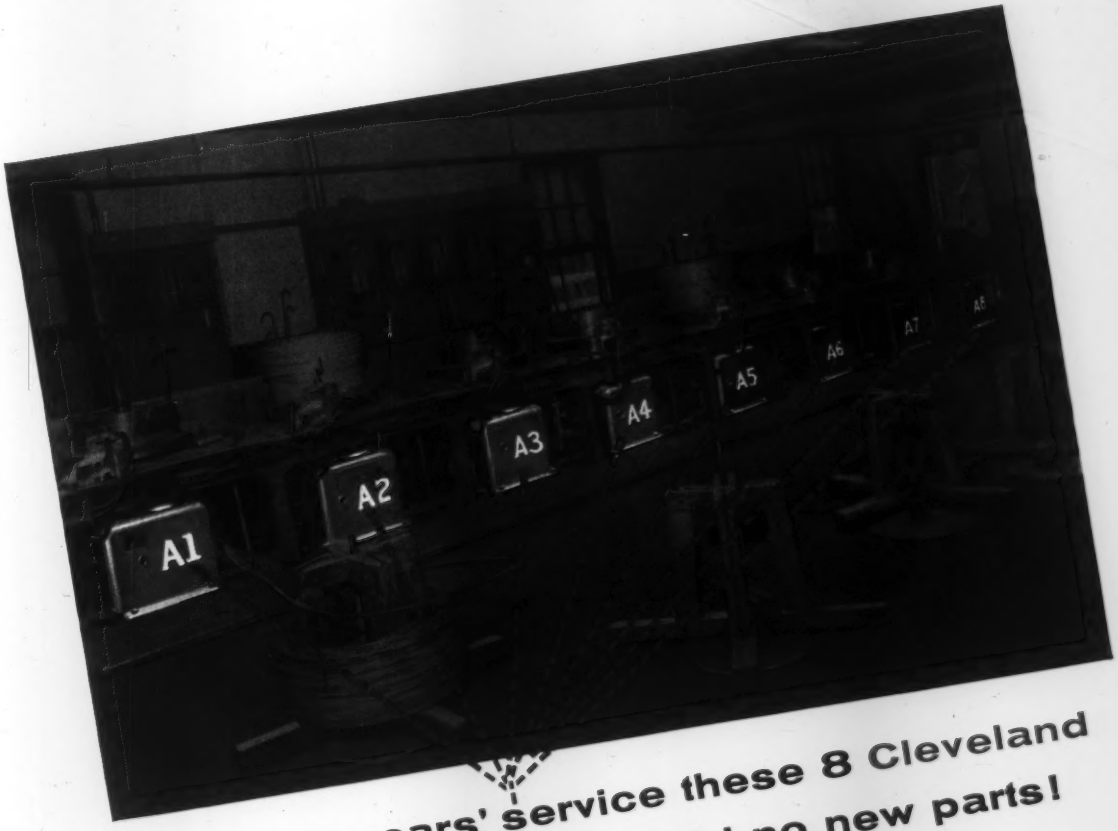

After 30 years' service these 8 Cleveland speed reducers needed no new parts!

Here are eight Cleveland Worm Gear Speed Reducers that have been on the job in this wire drawing plant continuously since 1929. Recently they were dismantled — then reassembled without *any* replacement of parts. Good for many more years of rugged service.

This is typical of the type service you can expect when Clevelands handle the right angle transmission of power in your plant. They save space and make for easy installation.

Before you buy machines or mechanize existing equipment, check and see what Clevelands can do to improve your operation. The complete story is contained in Bulletin #145. Write for your free copy, today.

The Cleveland Worm & Gear Company
3287 East 80th St., Cleveland 4, Ohio

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CLEVELAND
Worm Gear
Drives

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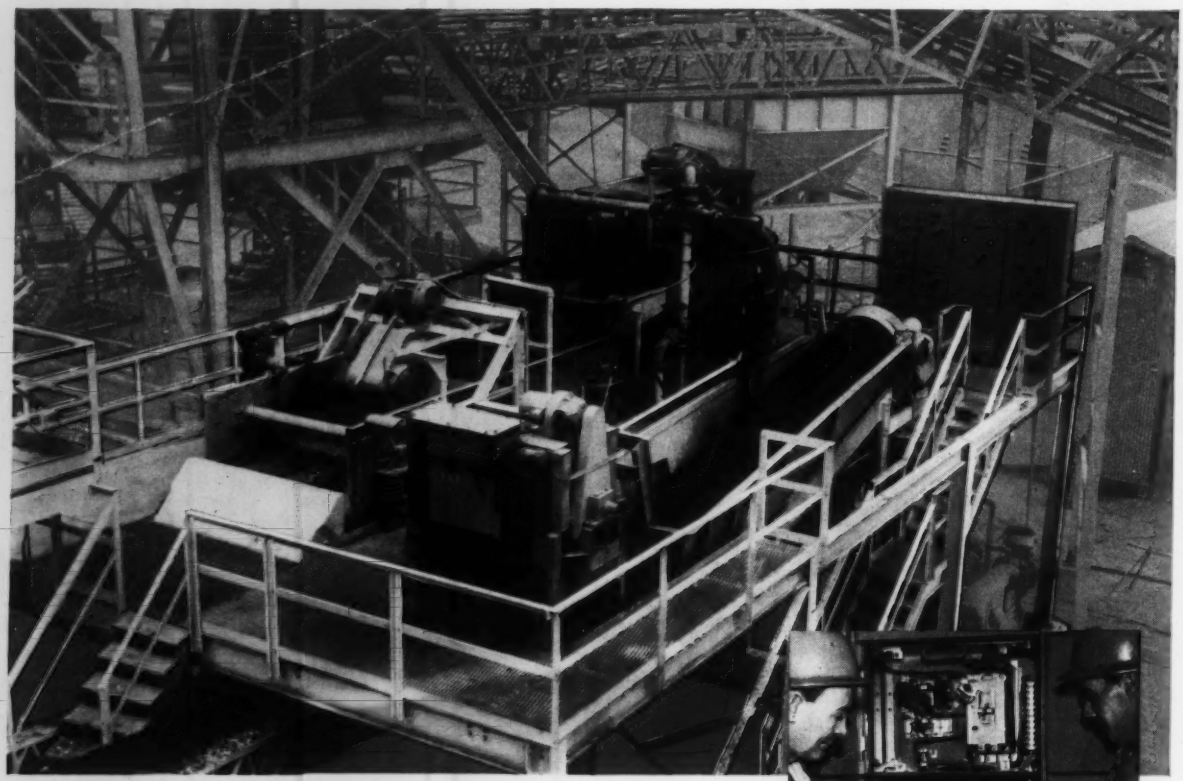

Unitrol control units are easily installed ... exclusive plug-in connector eliminates hazardous manual adjustments. Locked test position assures safe inspection and maintenance.

Versatile WEMCO HMS Mobil-Mill

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Western Machinery Company's WEMCO HMS Mobil-Mill has gained widespread recognition and preference by demonstrating its broad versatility, rugged dependability, and low capital investment per ton of capacity. Both metallic and non-metallic ores and minerals, gravels, coal, etc. can be *continuously* extracted from the unwanted material with minimum operating costs and attention. Ranging in sizes from 5 to 500 tons per hour capacity, WEMCO Mobil-Mills have performed successfully as complete production plants, pre-concentration units, and pilot plants.

To assure maximum flexibility and trouble-free performance of the electric motor driven equipment under all operating conditions, WEMCO Mobil-Mills are equipped with Cutler-Hammer Unitrol as standard original equipment. This compact control center cuts job-site wiring time and costs. Modular construction permits rapid alterations of the control units to keep pace with changing mill requirements. And vertical *dust-safe* contacts, indestructable molded magnet coils, and optional full three-phase 3 coil overload protection are typical plus features of Unitrol which guarantee unsurpassed performance and dependability.

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